United States Patent [19]

Castleman et al.

[11] **4,122,518**

[45] **Oct. 24, 1978**

[54] **AUTOMATED CLINICAL SYSTEM FOR CHROMOSOME ANALYSIS**

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[21] Appl. No.: **687,251**

[22] Filed: **May 17, 1976**

[51] **Int. Cl.**[2] **G06F 15/42**

[52] **U.S. Cl.** ..... **364/300**; 128/2 R; 364/120; 364/415; 364/900

[58] **Field of Search** ..... 444/1; 128/1 R, 2 R; 356/39; 235/151.3, 151; 364/200, 300, 900, 413, 415-417, 555, 496, 497, 120

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Patrick et al.; Computer Controlled Picture Scanning with Application to Labeled Biological Cells, Comput. Biol. Med. 1972, vol. 2, No. 1, pp. 5-14.

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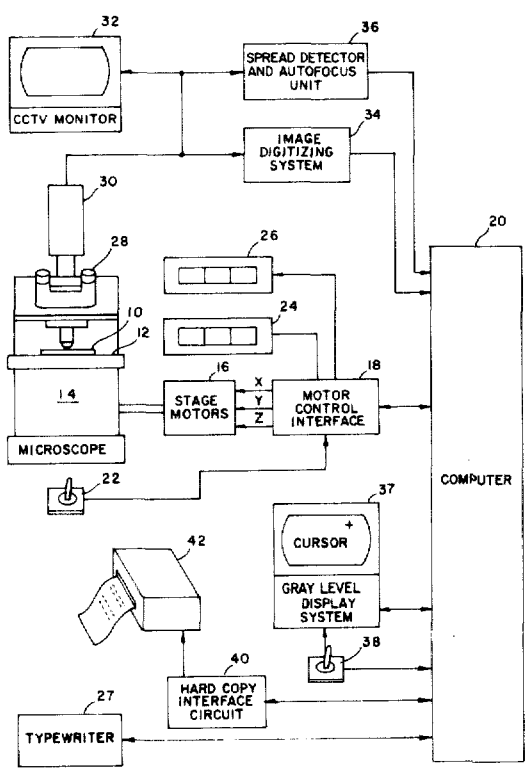
[57] **ABSTRACT**

An automatic chromosome analysis system is provided wherein a suitably prepared slide with chromosome spreads thereon is placed on the stage of an automated microscope. The automated microscope stage is computer operated to move the slide to enable detection of chromosome spreads on the slide. The X and Y location of each chromosome spread that is detected is stored. At the conclusion of this searching operation, the computer directs the microscope to again sequence through the chromosome spread locations in response to the stored X and Y locations. At this time an operator can view these spreads to determine which ones are worthwhile and which ones are not. He is provided with an accept-reject switch. The microscope stage thereafter again sequences through only the accepted chromosome spreads, and this time a digital photograph of each of the chromosome spreads is made and entered into the computer storage. The computer thereafter measures the chromosomes in a spread, classifies them by group or by type and also prepares a digital karyotype image. This image is converted to analog form, displayed and printed out and constitutes a primary output of the system. Chromosome measurement data is filed in an interactive data base for subsequent statistical analysis. The computer system can also prepare a patient report summarizing the result of the analysis and listing suspected abnormalities.

15 Claims, 4 Drawing Figures



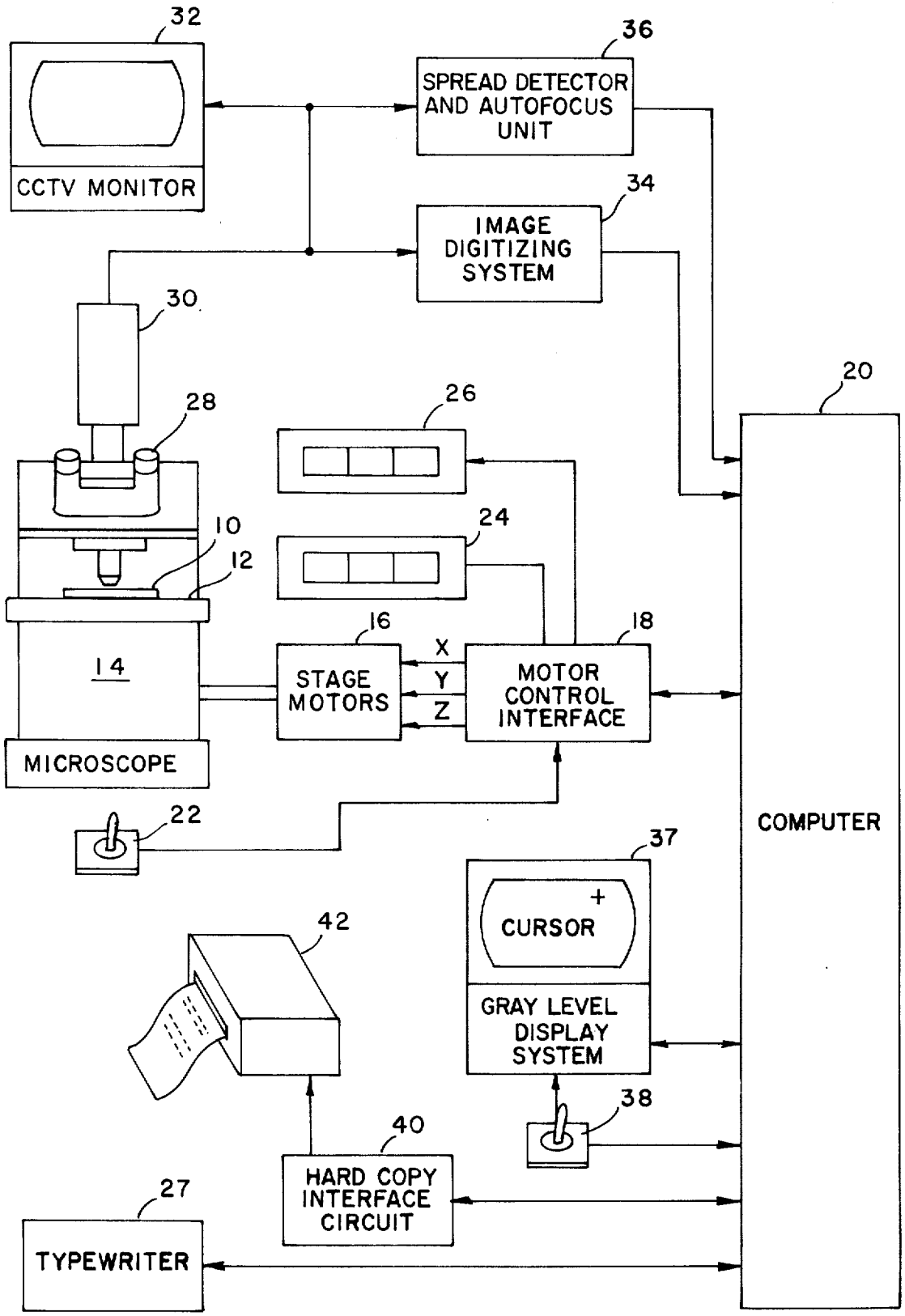

32
CCTV MONITOR
36
SPREAD DETECTOR AND AUTOFOCUS UNIT
34
IMAGE DIGITIZING SYSTEM
30
28
26
20
10
12
24
14
16
18
X
Y
Z
STAGE MOTORS
MOTOR CONTROL INTERFACE
MICROSCOPE
22
37
CURSOR
42
GRAY LEVEL DISPLAY SYSTEM
38
40
HARD COPY INTERFACE CIRCUIT
27
TYPEWRITER
COMPUTER

FIG. 1

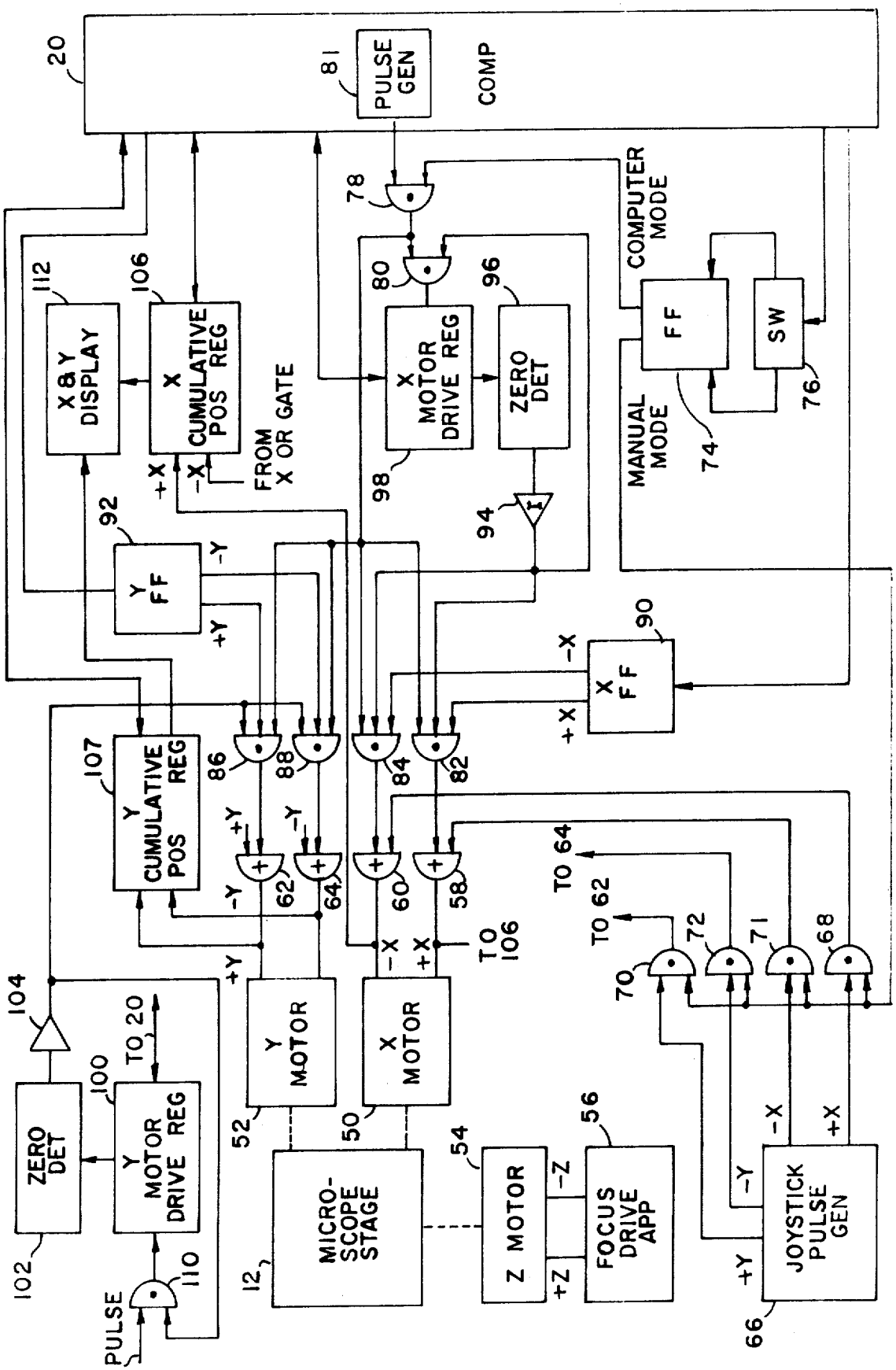

20
81
PULSE GEN
COMP
78
80
96
ZERO DET
X MOTOR DRIVE REG
98
94
COMPUTER MODE
MANUAL MODE
FF
SW
74
76
112
X & Y DISPLAY
106
X CUMULATIVE POS REG
+X
-X
FROM X OR GATE
92
Y FF
-Y
+Y
90
X FF
-X
+X
107
Y CUMULATIVE POS
86
88
84
82
62
64
60
58
TO 106
TO 64
TO 62
72
71
68
70
104
TO 20
100
Y MOTOR DRIVE REG
ZERO DET
102
110
PULSE
Y MOTOR
X MOTOR
52
50
54
56
MICRO-SCOPE STAGE
12
Z MOTOR
-Z
+Z
FOCUS DRIVE APP
JOYSTICK PULSE GEN
66

FIG. 2

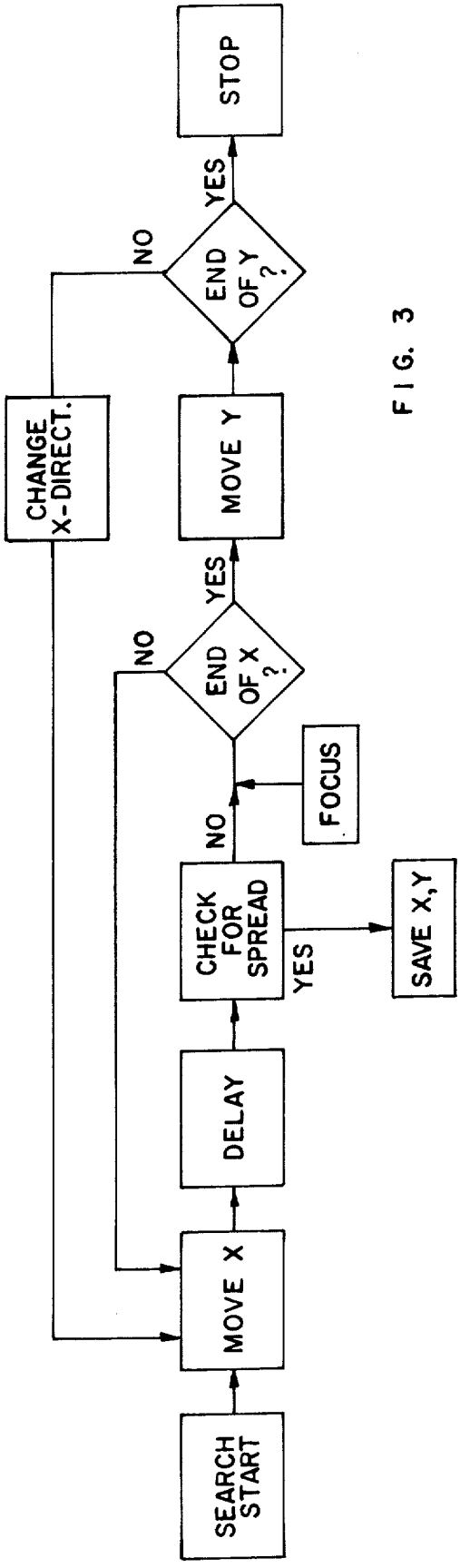

SEARCH START
MOVE X
DELAY
CHECK FOR SPREAD
YES
SAVE X,Y
NO
FOCUS
END OF X ?
NO
YES
MOVE Y
END OF Y ?
NO
YES
CHANGE X-DIRECT.
STOP

FIG. 3

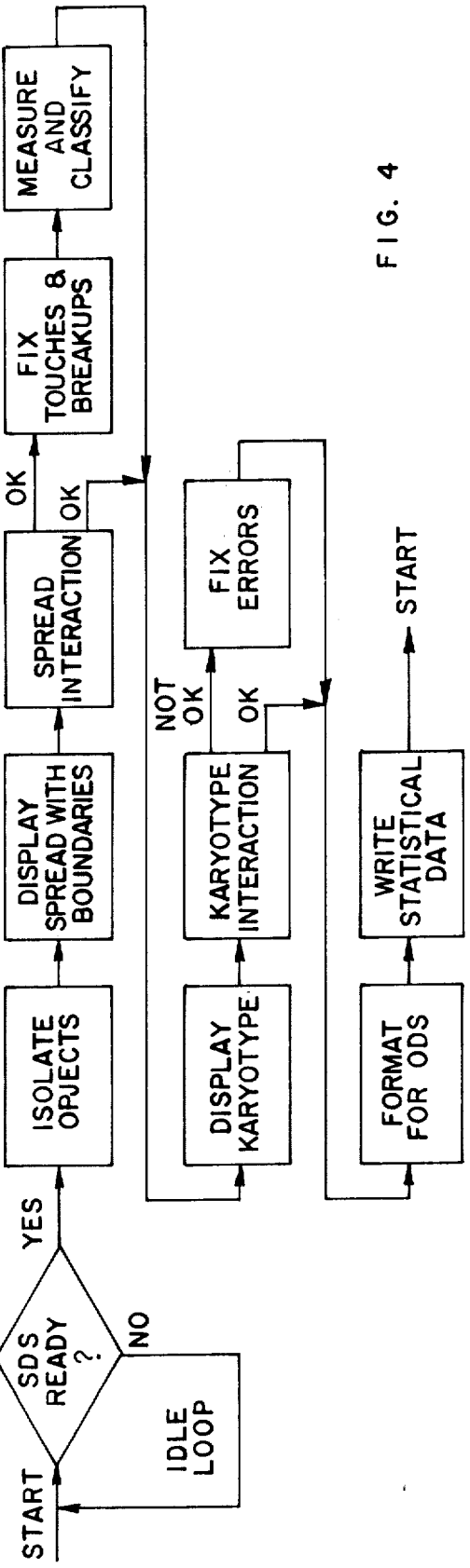

START
SDS READY ?
NO
IDLE LOOP
YES
ISOLATE OBJECTS
DISPLAY SPREAD WITH BOUNDARIES
SPREAD INTERACTION
NOT OK
OK
FIX TOUCHES & BREAKUPS
MEASURE AND CLASSIFY
DISPLAY KARYOTYPE
KARYOTYPE INTERACTION
NOT OK
OK
FIX ERRORS
FORMAT FOR ODS
WRITE STATISTICAL DATA
START

FIG. 4

AUTOMATED CLINICAL SYSTEM FOR CHROMOSOME ANALYSIS

ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435; 42 USC 2457).

BACKGROUND OF THE INVENTION

This invention relates to automated medical analysis equipment and more particularly to improvements therein.

Since the introduction of a method allowing microscopic examination of individual human chromosomes, the karyotype has emerged as a tool of increasing diagnostic value. Under microscopic examination, the chromosomes, from a somatic cell in the metaphase stage of cell division, appear in scattered disarray. The karyotype is a systematic grouping of metaphase chromosomes from a single cell. This grouping was conceived to assist the geneticist in the identification of individual chromosomes. In normal humans, the 46 chromosomes can be reliably ordered into 24 types (seven groups). The diagnostic value of the karyotype is predicated upon the existence of a consistent pattern in normal patients and the correlation of certain chromosomal aberrations with specific clinical observations. There are two types of chromosomal irregularities: numerical and structural. Numerical aberrations exist when the number of chromosomes in one or more groups differs from the normal case. Structural aberrations manifest themselves in many forms, some presumably unobserved as yet. Those which presently merit nomenclature, amongst others, include variations in arm length and centromere position.

At present, manual karyotyping is so tedious and expensive that its general application is usually limited to those situations involving a suspected abnormality. In these circumstances, the clinical evidence is often so overpowering that the karyotype serves primarily as a corroborative tool. In a addition, manual karyotyping offers little prospect of quantitative data. It is desirable to extend karyotype analysis to the clinically asymptomatic situation. For example, screening all newborns by karyotype may detect certain inherited disorders long before clinical symptoms appear. As the potency and reliability of the karyotype improves, fetal karyotyping through amniocentesis may become a routine part of prenatal care. Screening studies on large populations offer the potential of uncovering the effects of industrial and environmental poisons, aging, and long term low dosage ionizing radiations. These factors may manifest themselves in subtle structural aberrations requiring detailed analysis of the chromosome morphology. The ability to process cells rapidly and inexpensively would also aid in the detection of mosaicism, in which two or more cytogenetically distinct lines of cells exist in the individual.

There are certain functional requirements for an automated chromosome analysis system which should be met before widespread acceptance thereof can be anticipated. One of these is that the system should be compatible with current practice producing results compatible with those obtained with the present manual system of analysis. Further, the system should provide significant

time savings in processing cytogenetic specimens without sacrificing accuracy. Its cost should not be prohibitive and it should be accurate.

OBJECTS AND SUMMARY OF THE INVENTION

An object of this invention is to provide a system for automating chromosome karyotyping.

Another object of this invention is to provide an automated chromosome analysis system which is compatible with current practice.

Still another object of this present invention is one which operates rapidly without sacrificing accuracy, and which reduces the cost.

The foregoing and other objects of the invention are achieved in a system wherein a previously prepared slide, which has a number of chromosome spreads is mounted on the stage of a microscope. Under instructions of a computer, a search of the slide is undertaken to locate the various chromosome spreads on the slide. The spread locations are stored. At the end of the slide search, it is again initiated with the stage of the microscope being stopped at each chromosome spread location, to enable a human observer to inspect the chromosome spread and determine whether it is acceptable for the purpose of analysis or not. If it is not acceptable the observer pushes a button whereby its location is removed from the spread storage list and the microscope stage is moved to the next location. The microscope automatically focuses at each location.

After all of the chromosome spread locations have been inspected, the microscope is again actuated to move its stage so that each one of the accepted chromosome spreads are passed under the optics of the microscope for the purpose of enabling digital pictures of the various spreads to be generated and stored in memory. The computer then proceeds to locate and analyze the chromosomes in each of the chromosome spreads by measuring the chromosomes, classifying them by group or by type and preparing a digital karyotype image format. This image is then converted to pictorial form and displayed on an image display tube to enable any corrections, if needed. A joystick control is provided so that a cursor, which is produced on the display tube screen can have its position moved whereby the operator an point out to the computer objects in the image which he wants removed or chromosomes which need repositioning. Communication with the computer is made using a typewriter. The corrected karyotype image is then printed out. Provision is also made for a printout of the computer analysis of the optical image derived from a slide.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic drawing of a chromosome analysis system, in accordance with this invention.

FIG. 2 is a schematic drawing of the apparatus used to drive the microscope stage.

FIG. 3 is a flow chart illustrative of the searching and detecting operation, in accordance with this invention.

FIG. 4 is a flow chart illustrating the analysis operation in accordance with this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is a block schematic diagram of the configuration of the system in accordance with this invention. The preparation of glass slides containing stained meta-

phase chromosome spreads suitable for use with this invention is known. The slides can be prepared by different techniques, such as the homogeneous Giemsa staining technique or by the Trypsin-Giemsa banding technique. Slides are produced with patient identification marks. A specimen slide **10** is placed on the stage **12** of a microscope **14**. The stage **12** is motorized, that is it is capable of being driven in the X, Y and Z directions by three stage motors **16**. The stage motors may either be controlled via a motor control interface circuit arrangement **18**, from a computer **20**, or by a stage joystick **22**, when it is enabled to control stage position. A stage keyboard **24** enables an operator to select the mode of operation desired, that is, either computer mode or operator mode. Control of the selection is normally with the operator; however the computer has the option to override the operator mode and/or to inhibit subsequent selection of the operator mode. The mode of operation is displayed by a stage display **26**. A typewriter **27** serves to enable entry of data, instructions or queries into the computer or to receive data from the computer.

The configuration of the optical imaging system of the microscope allows the specimen to be viewed simultaneously through a binocular eyepiece **28** and by a television camera **30**. The output of the television camera is applied to a monitor **32**, to an image digitizing system, **34** and also to circuitry designated as "Spread Detector and Auto Focus Unit" **36**.

The Spread Detector and Auto Focus Unit **36** comprises circuitry which serves the function of detecting the presence of a chromosome spread and also for automatically focusing the television camera equipment for performing these functions is described in an article entitled "Metaphase Spread Detection and Focus Using Closed Circuit Television," by Johnson and Goforth, published in *The Journal of Histochemistry and Cytochemistry* in 1974, by the Histochemical Society, Inc. The Image Digitizing System **34** serves the purpose of digitizing the image being viewed by the television camera which is then entered into computer memory. The computer **20** processes each digital image, as will be described and arranges each image in a karyotype format. A gray level display system **37** displays a karyotype image the information for which is supplied by the computer. A joystick **38** associated with the gray level display system is used for positioning a cursor at a location on the face of the display system for the purpose of pointing out certain locations or objects in the display to the computer. The computer can then be instructed by the typewriter to correct the object designated by the cursor, i.e. correct or erase, etc.

The hard copy printout of a karyotype image is produced in response to the corrected karyotype information received from the computer. This is applied to the hard copy interface circuit **40**. This constitutes a circuit for converting the corrected digital karyotype digital signals to analog form and the associated timing required for enabling the hard copy output device **42**, wich is essentially a facsimile printer, to print out a karyotype picture from the analog signals.

FIG. **2** is a block schematic diagram illustrating the circuits used in controlling movements of the motorized stage of the microscope. The stage is driven in the X, Y and Z directions respectively by three motors **50**, **52**, and **54**. The Z motor is driven in the +Z or −Z direction by signals from the computer in response to focus drive apparatus **56** in the Spread Detector and Autofocus Unit **36** (FIG. **1**). Both X and Y motors are driven in the +X or −X directions and +Y or −Y directions in response to outputs froma +X Or gate **58**, or a −X Or gate **60** and a +Y Or gate **62**, or a −Y Or gate **64**. The inputs to these Or gates, come either from the computer **20**, through logic circuits to be described or from the joystick pulse generator **66**, as determined by whether the operation is to be in the manual mode or the computer mode.

In the manual mode, the direction in which the joystick is moved determines whether pulses are provided on a +X, or a −X or a +Y or a −Y line. +X and −X pulses are applied, in response to joystick motion, from the joystick oscillator to And gates **68** and **71** respectively. These And gates are enabled in response to the output of a mode flip flop **74**. When flip flop **74** is set by means of switch **76** to its manual mode, then And gates **68** through **72** are enabled. The other output of the flip flop indicates that the system is in its computer mode. Flip flop **74** can be set in its computer mode by means of a manual switch **76**, or the computer can override the switch **76** if a situation arises where computer operation must be maintained.

When in the computer mode, the output of flip flop **74** enables an And gate **78** to transfer pulses received from a pulse generator **81**, within the computer **20**, to another And gate **80**, and also to four And gates **82**, **84**, **86** and **88** whose outputs respectively provide pulse inputs to the Or gates **58**, **60**, **62** and **64**.

And gates **82** and **84** are three input And gates. One of the inputs required to enable And gate **82** is the output of an X direction flip flop **90**. The computer determines which direction the stage is to move, when the system is in the computer mode,and for one direction sets flip flop **90** with its +X output whereby And gate **82** receives one of its two required enabling inputs. The computer sets the flip flop with its −X output high for the opposite direction, whereby And gate **84** receives one of its two required enabling inputs. Similarly a Y direction flip flop **92** is provided which for one direction is set with its +Y output high thereby providing one of the two enabling inputs required by And gate **86**, and for the opposite direction its −Y output is high whereby And gate **88** receives one of two required enabling inputs.

The second required enabling input to And gates **82** and **84** is provided by an inverter **94**, which is driven by the output of a zero detector **96**. The zero detector senses when an X motor drive register **98** has reached zero at which time it supplies an output to the inverter **94** whereby And gates **82** and **84** are disenabled.

A similar function is provided by a Y motor drive register **100**. When it reaches zero, this is sensed by a zero detector **102**. The zero detector output drives an inverter whereby And gates **86** and **88**, which are otherwise enabled becomes disenabled.

The absolute X position of the microscope stage **12** is maintained by an X cumulative position register **106**, which can provide this information to the computer. The X cumulative position register is a reversible counter which can receive +X and −X pulses which are applied to the X motor **50**, whereby the X cumulative position register is driven to retain the exact X position of the microscope stage. The computer generates an X coordinate number representing the location to which it desires the microscope stage to move in the X direction. This number is subtracted from the number in the X cumulative position register. The difference

represents the distance along the X axis, the microscope stage must move and also represents the number of pulses required to complete such a move. This number is entered into the X motor drive register **98** by the computer. The pulse generator **81** is then instructed to commence supplying pulses, and if And gate **78** is enabled, as it should be in the computer mode, then these pulses are applied through And gate **80** to the X motor drive register, causing it to count down towards zero. These pulses from the pulse generator **81** are also applied to all of the And gates **82**, through **86**.

Since the motor drive register is in its non-zero state, until it has counted down to zero, the one of the two X And gates **82**, **84** which is enabled by the X direction flip flop **90** will be able to apply pulses to the X motor causing it to drive the microscope stage. When the X motor drive register reaches zero, this is detected, and the And gate which has been applying pulses to the X motor is disenabled.

The circuitry for driving the Y motor in the computer mode is the same as the circuitry used for driving the X motor in the computer mode. A Y cumulative position mode register **107** retains the absolute Y position of the microscope stage **12**. It is driven in response to the same pulses which are applied to the +Y and −Y inputs to the Y motor **52**. This cumulative position is supplied to the computer which determines the location along the Y axis to which it desires the microscope stage to move. This is subtracted from the Y cumulative position information and the difference is applied to the Y motor drive register by the computer. Pulses from the pulse generator **81** are applied to an And gate **110**, which is enabled when the Y motor drive register is not in its zero position. These pulses start to drive the Y motor drive register and are also applied to the +Y and −Y And gates **62** and **64**. The one of these two which is enabled is determined by the output of the Y flip flop **92**.

Accordingly, the Y motor is driven until it reaches the position determined by the computer at which time the Y motor drive register will be at zero. This is detected by the zero detector with the consequent inverter output **104** disenabling the one of the two And gates which was enabled by the Y flip flop **92**. Also, no further pulses are applied to the Y motor drive register.

Both the X and Y cumulative position register outputs are applied to an X and Y display **112** to be visually displayed. The display comprises apparatus which converts the digital information in the X and Y cumulative position registers into visual information.

FIG. **3** is a flow chart exemplifying the search mode of operation. When the computer starts a search the circuitry shown in FIG. **2** is instructed to move a predetermined amount in the X direction. In the embodiment of the invention which was constructed, each step of motion in either X or Y direction is 10 microns, however each move instruction from the computer in either the X or the Y direction is a 160 micron move. The field of view is 200 microns square, and a cell containing chromosomes is on the order of 80 microns in diameter. Accordingly, the instruction by the computer to the circuitry shown in FIG. **2** is to move the stage 160 microns in the X direction and then to institute a delay in order to focus and to permit the spread detector to determine if a spread is present in the field of view. If there is a spread the X-Y coordinates of that location are stored by the computer.

Next, a test is made to see if a limit of X travel which is the end of the X line has been reached. If it has not been reached, then the computer issues an instruction to move the next 160 microns in the X direction. If the end of the X line has been reached then a Y move instruction is issued. At the time of issuing the Y move instruction a test is made to see whether or not a limit of Y travel has been reached. If it has been reached, then the search mode is terminated. If it has not been reached, then an instruction to change the X direction is issued. The computer then moves in the Y direction and changes the X direction of motion by applying a signal to drive the X flip flop **90**. Thereafter the microscope stage moves until it reaches the end of the new X line where the foregoing routine recurs.

To clarify the foregoing, in the search mode the microscope stage is moved from the beginning to the end of one line. It is then instructed to move in the Y direction to the end of the adjacent line, and then instructed to move in the X direction back to the beginning of that adjacent line. At the beginning of that adjacent line the microscope stage is moved again in the Y direction one line and then starts again in the X direction towards the end of the line to which it has been moved. The microscope slide is scanned in this manner from top to bottom over the entire area to be searched.

Automatic focusing is carried out each time a chromosome spread is detected.

The television camera **30** scans a spread seen through the microscope and displays this on a monitor **32**. The spread may also be viewed through the microscope viewing lens **28**. Thus, during the editing mode, the operator can use either or both means for editing.

After the editing mode, the system goes into its scanning mode. It sequences the microscope stage to the locations of the chromosome spreads which have been accepted, automatically focuses the image, and digitizes the spread image into a scan data set (SDS). The digitization is accomplished by the television camera **30** and the image digitizing system **36**. This equipment is commercially available and, by way of example, in an embodiment of the invention which was built, this equipment, called the model **108** Computer Eye, was furnished by a company called Spatial Data Systems, Inc. The camera scanned the image at the standard television rate (525 lines, 60 frames per second, interlace 2:1) and produced a video signal which was monitored on the television display. The brightness value in the scan picture is sampled at each point of a 512 by 480 grid and converted to a 7-bit binary number. Points anywhere in the picture may be selected on the program control, or the digitization can proceed through all points in sequence. A cursor is displayed on the monitor to show the points to be digitized.

As soon as the computer detects the presence of a spread image in one of the scan data sets provided by the image digitizing apparatus, it enters into its analysis mode. If the spread image is not to be karyotyped, the chromosomes are located, counted and displayed to the operator for verification. However, if the cell is to be karyotyped, a sequence of programs are executed to effect the karyotype analysis of the cell. These programs locate the chromosomes in a cell, orient them, extract measurements, classify the chromosomes and compose the digital karyotype. After the chromosomes have been isolated, they are displayed on the gray level display device **37** along with sequence numbers to allow the operator to correct cases of chromosome touching

and fragmentation. The karyotype is also displayed to allow the operator to verify correct classification. After the karyotype has been approved by the operator, it is formatted for output, combined with the spread image and copied into one of the output data sets. The analysis phase processes cell images one at a time from a raw spread image to digital karyotype.

FIG. 4 represents a flow chart illustrating the steps in the analysis phase of operation which have just been described. SDS stands for scan data set. Each chromosome is tagged with a number. Where operator intervention is required, in the case of the spread interaction or karyotype interaction, where break ups are to be fixed or chromosomes are touching, or other problems. The operator moves the interactive joystick to the location of a picture element which required correction. The operator then, by means of the typewriter **27**, types an instruction to the computer in response to which the computer performs the required operation.

The gray level display system presents a picture of the chromosome spread which has been organized into the standard karyotype format for ease of diagnosis. Similar pairs of autosomes are collected and numbered with homologous pairs being numbered from **1 - 22** and similar pairs being collected into groups lettered A through G based on similar morphology.

The gray level display device is a 1029 line television monitor driven by a scan converter called a Hughes 639 scan converter. This is provided by the Hughes Aircraft Co. with instructions for its use and its operation.

Hard copy printout is achieved by converting the digital elements into analog signals by the circuits **40**, which are applied to the hard copy output device. This comprises essentially a facsimile recorder.

There has accordingly been shown and described above, a novel and useful system for scanning chromosome spreads detecting those spreads; editing the detected spreads. Thereafter digitizing the spread images, analyzing, classifying and placing a spread in a karyotype format. This format is displayed on a gray scale display for final correction. Then a hard copy printout of the corrected karyotype image is provided.

The Appendix that follows provides a specific description of the computer programs as well as a copy of the program, in the FORTRAN language, used on a DEC PDP-11 computer for performing the operations described. The computer is made by Digital Equipment Corporation, One Iran Way, Marlborough, Mass. This is to be considered as exemplary and not as limiting. The program can be translated for use on other types of general purpose computers, made by other manufacturers by those skilled in the art.

The chromosome indentification technique, that is a general description of a method of chromosome identification which was implemented by the programming is described in a volume entitled *Chromosome Identification* edited by Torbjorn, Casperson and Lore Zech, which is a publication of Proceedings of the Twenty-Third a Noble Symposia published by the Academic Press in 1973. The chromosome analysis procedure which was implemented by the programming is generally described in *Perspectives in Genetics*, edited by S. W. Wright et al., and published in 1972, by Charles C. Thomas.

APPENDIX

The computer has a core memory and the software fits into 64K bytes of core memory. It also has three disk drives each of which has two 2.5 million byte disk cartridges. The core memory is partitioned so that it can simultaneously perform three tasks; slide search, chromosome spread analysis on a recorded digital picture of a chromosome spread; and pictorial output generation of an analyzed chromosome spread. All software runs under a disk operating system monitor supplied by the manufacturer, as well as maintenance and interactive statistical analysis. Automatic keryotyping runs under a specially written supervisor (CALMS).

CALMS

Purpose: Clinical ALMS supervisor - Controls slide search, scanning, analysis and hardcopy output of karyotypes or counts.

The CALMS supervisor controls the three "partitions," search, analysis, and hardcopy.

The supervisor occupies core from **30000** to **37777** and includes the hardcopy driver. The search partition is permanently resident at locations **40000** to **46777**. System subroutines are permanently resident at locations **47000** to **57777**.

Scan and analysis consist of **20** phases that residue on disk in core-image format. One phase at a time is loaded into locations **60000** to **156777** and called by the supervisor. (Locations **157000** to **157775** may be used for COMMON storage.)

Each analysis phase has a unique identifying number, from **1-20**. Scan is phase **1**, binary is phase **2**, etc. The data set CALMS.OVR is used to store the phases. Each phase required 63 blocks. Program OVB is used to store a phase in CALMS.OVR after it has been linked with a bottom switch of **60000**.

The following batch stream builds scan (phase **1**):

```
$JOB [2,2]
$R LINK
#DK5:PHASE/CO,LP:/SH<CALMS,STB,-
  SCAN,EXIT,FTNLIB/B:60000/E
$R OVB
*1
$FI
```

Similar batch streams build the other phases.

An Analysis phase is loaded into core and then called as if it were a subroutine. The disk unit, file name and extension of the current scan data set are passed as parameters. The phase must return to the CALMS supervisor when it is finished. This can be done with a return statement in a subroutine or a call to the CALMS EXIT subroutine from a main program.

The following symbols are used to define the scan and hardcopy data sets.

NSDS = **3** # of scan data sets
NHDS = **2** # of hardcopy data sets
SDU = **5** scan disk unit (DK5:)
HDU = **3** hardcopy disk unit (DK3:)

The scan data sets are named S1,S2,S3. The hardcopy data sets are named H1,H2. They are stored under UIC [2,2]. Allocation of data sets is done by:

NFSDS: .WORD .-. # full scan data sets (F)
SDS: .BLKB NSDS if NFSDS contains F (F>0) the first F bytes contain the data set numbers (1=S1, 2=S2, etc) ordered by time of scan.
HDS: .BLKB NHDS each byte gives the status of a particular data set:
0 = available
1 = in use by mask
−1 = full (ready for hardcopy output)

When CALMS calls the MASK phase, it gives the current hardcopy data set as a parameter, instead of the current scan data set. When MASK returns, CALMS calls HCOPY, unless it is already operating. Whenever HCOPY finishes, it checks to see if another hardcopy data set is full, and if so, it starts to process it.

HCOPY and SEARCH are interrupt-driven and must not call any non-reentrant DOS routines, because the routine they call might be the one that was interrupted.

OPEN results in a call to the .INIT routine which is not re-entrant because it gets buffer space for a DDB. Therefore, HCOPY and SEARCH cannot call OPEN.

CALMS initially opens all the hardcopy data sets to find their start block numbers and saves them in the HSBN table.

The CALMS supervisor flow chart illustrates its operation. The 'idle loop' starts at S10 and the program will cycle until a spread can be scanned or analyzed, or a special request has been made (See Flow Chart 1).

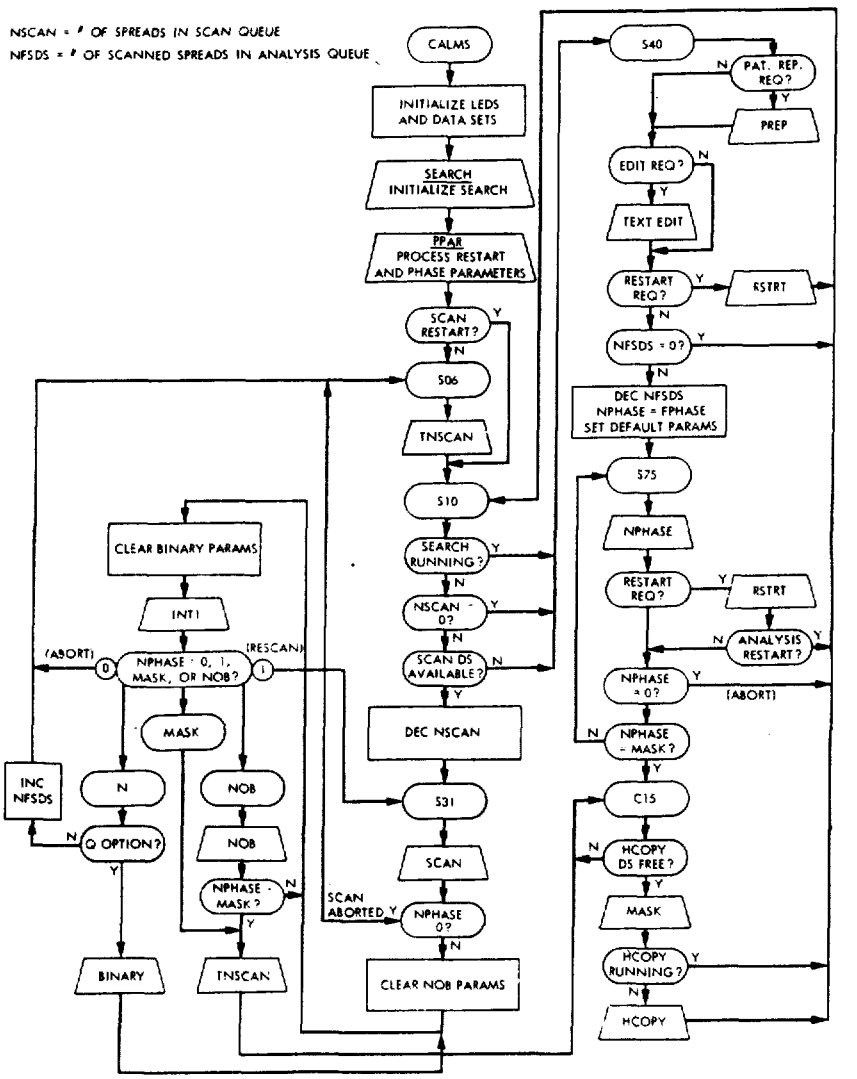
After a spread is scanned, the program INT1 is called. If the operator only wants to do a count, the spread will not be placed in the analysis queue, and the counting and masking are done at this time.

If the spread is to be karyotyped, it will be added to the analysis queue, but if more spreads are to be scanned (and scan data sets are available), they will be scanned before analysis begins. When all spreads on a slide have been scanned, a new slide can be searched while spreads from the previous slide are karyotyped.

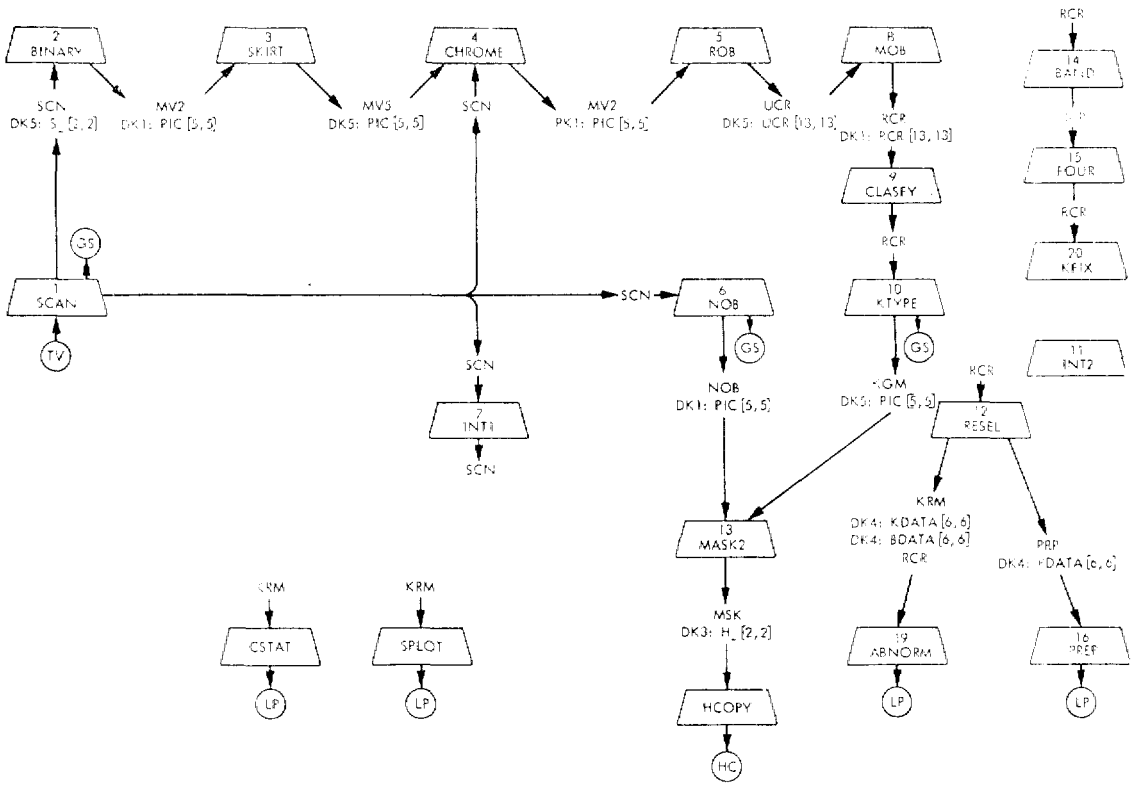
Flow Chart 2 details the flow of data through the various program and data sets during the karyotyping process.

The analysis loop begins at S75, and CALMS stays in this loop until the MASK phase is called (or a restart or abort is requested).

After MASK is called, CALMS starts the hard copy partition (unless it is already running), and returns to the "idle loop."



FLOW CHART 1



FLOW CHART 2 CALMS Data Flow

SEARCH

Purpose: Slide search edit, and focus. SEARCH partition of CALMS

SEARCH controls the microscope stage and handles the interrupts from the special-function keyboard and spread/focus data ready. Initially, CALMS calls SEARCH to set up some of the interrupts. Thereafter, SEARCH is interrupt-driven.

The operator presses SEARCH start on the special-function keyboard to start a search. Patient ID, sex, slide ID, and source are entered from the typewriter, before the SEARCH actually starts. The SEARCH pattern is a boustrophedon. Each step is 160 microns, and 60 horizontal steps are taken, before a vertical step is taken. Thus, the slide is searched in rows.

SEARCH is entered via the spread/focus data ready interrupt, after each step. If the "spread" bit is on, the X and Y values are saved in the spread queue, SPQ. SEARCH will perform an auto-focus whenever 15 steps have elapsed since the last auto-focus, and there is something to focus on.

The operator can manually halt the search with the SEARCH halt key. He can then move to another area of the slide and resume the search by pressing SEARCH resume. SEARCH disables the spread/focus data ready interrupt when it receives a SEARCH hlt interrupt, and re-enables it for SEARCH resume.

The SEARCH is terminated when 300 spreads have been found, or when the operator presses the edit-start key.

Normally, both SEARCH and edit are done at 63X, and there is only one edit. (There is also an option to search at 40X and do a "low-magnification" edit at 40X, followed by a "high magnification" edit at 100X).

Edit moves the stage to each spread location saved in the spread queue and initiates an auto-focus sequence. The operator can reject the spread before the auto-focus sequence finishes, and edit will immediately move to the next spread in the queue. If the auto-focus sequence finishes, edit turns on the operator action light and waits for the operator to press "accept," "reject," "next" or "last."

The operator normally centers the spreads he wishes to accept. When the accept key is pressed, edit saves the X and Y values in the same place in the queue and flags them by setting them negative. It also increments the rating for the spread by one each time the accept key is pressed. The ratings are stored in a byte table named SPR.

When the reject key is pressed, spread rating is zeroed and the X and Y values are made positive. The stage is then moved to the next spread.

The next key causes edit to move to the next spread without altering the accept-reject state.

The last key causes edit to move to the previous spread.

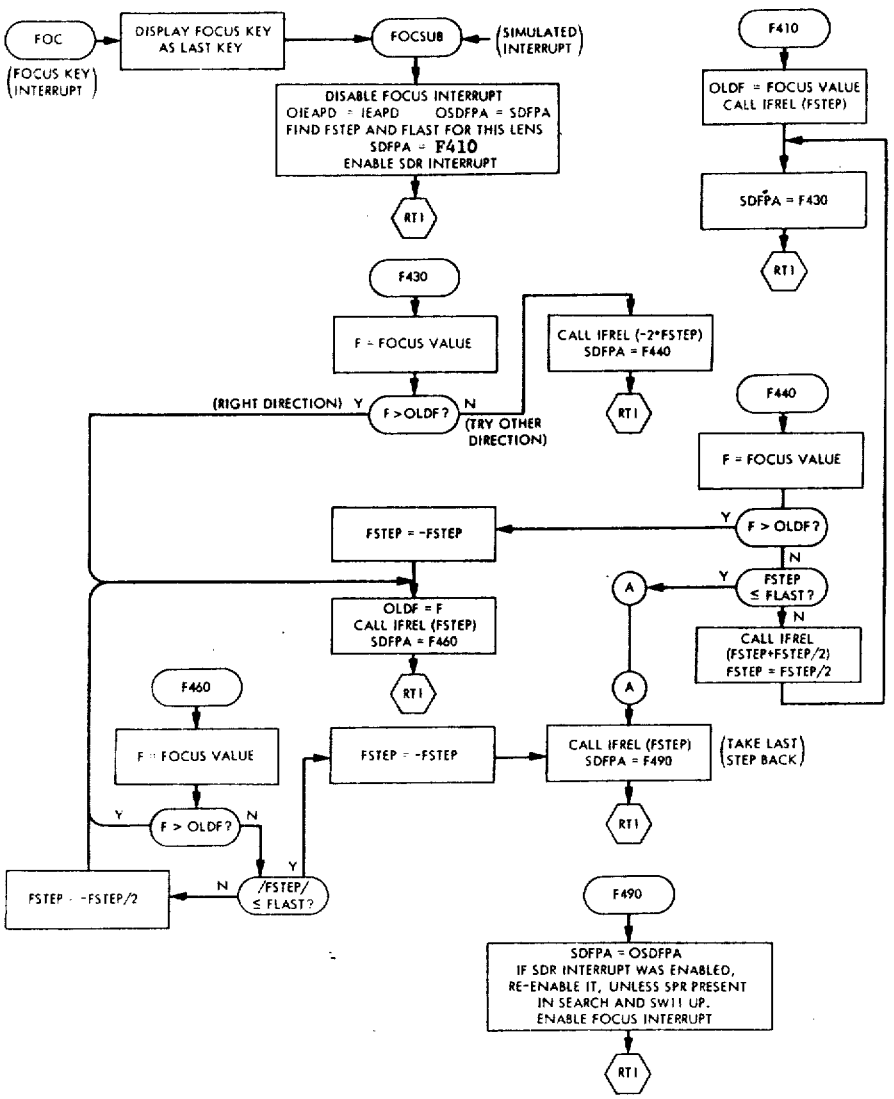
The edit finishes when the end of the queue is reached, or when the operator presses edit-end. The queue is then sorted according to rating. The highest rated spread is moved to the start of the queue, and the stage is moved to this spread in preparation for the first scan. At this point, the queue and other critical information is saved, by calling WPARAM for phase one. This allows a scan restart at a later time.

GNSTS is the entry point for the "get next spread to scan" subroutine. It initiates a motor move and auto-focus on the next spread in the scan queue. CSPQ contains the current location. It also enables a spiral search,

if search start is pressed. The spiral search is useful in locating a spread close to known coordinates. It takes steps of 50 microns in a spiral pattern and focuses when there is something to focus on. The operator can halt it or resume it with the search halt and resume keys.

The focus routine can be entered via the focus key interrupt, or it can be called as a subroutine via a simulated interrupt. It operates by initiating focus motor moves and executing an RTI instruction, after setting up the spread/focus data ready interrupt. When the move is completed, it is reentered and compares the new focus value with the old one to see what the next move should be. Each lens has an initial and final step based on its magnification. The step size is decreased until the final step size is reached. The focus flow chart illustrates the algorithm.

(See Flow Chart 3).



FLOW CHART 3 Focus

SCAN

Purpose: To scan a picture onto disk, display it on the gray scale, and calculate sector thresholds.

SCAN uses the SDS data camera to scan a picture onto a disk. The picture is scanned by columns, with alternating even and odd TV fields, to achieve the minimum scan time of 17 seconds. Each column is assembled in core and output as a line on disk and on the gray scale. The coils on the SDS monitor have been rotated so that the orientation is the same as on the gray scale monitor.

Sector histograms are accumulated as the picture is scanned, and sector thresholds are calculated at the end of each row of sectors. The thresholds are typed out if SW1 is up. The thresholds are written after the last picture line.

SCAN sets priority 6 during the pixel digitization loop to prevent interrupts from other devices which would cause it to lose "sync." Hardcopy interrupts (which are at priority 7) are the only ones allowed, due to their critical nature. When the hardcopy is running, the SCAN takes several seconds longer.

SCAN converts pixel values of 0 to 1, and values of 127 to 126. This allows cut and join lines to be differentiated from normal data values.

SCAN stores the source code, patient ID and sex, slide ID, X and Y values, date and time of scan into the label of the output data set.

The operator may enter additional information as the SCAN ID.

BINARY

Purpose: To segment the chromosomes and generate an edge file containing the end point coordinates for each segmented chromosome.

BINARY will read in a scanned spread and assemble a reduced core image of binary sample points. Each sample point is obtained by averaging a 2×2 pixel area. If this average is above the sector threshold, then the sample point is recorded as a 1-bit. Otherwise, a zero bit is recorded. Thus a digitized spread of 500×480 pixels is reduced to a 250×240 grid of sample points. The resulting binary image is surrounded with zero bits to provide a physical boundary to keep the perimeter walker used in the segmentation algorithm from wandering off the edge of the picture. The binary reduction is accomplished through multiple calls to the subroutines QTHR or STHR.

After the binary image has been completely assembled in core, it is scanned line-by-line for chromosomes (1-bits). Each chromosome is "segmented" by recording its starting and ending coordinates on each scan line. Provision also exists for multiple segments to occur on any given line. (See Flow Chart 5)

The segmentation algorithm is implemented in the subroutine SEGMENT, which scans the binary image line-by-line for chromosomes. The search is performed by ROACH, which scans each line from left to right, stopping only when it encounters a chromosome. The starting bit location of any chromosome found is recorded and control is transferred to the subroutine TURTLE. TURTLE will walk counterclockwise around the perimeter of the chromosome, recording the segment end. point coordinates as it proceeds. Since the coordinates are recorded in the order they are encountered along the perimeter, they must be rearranged so that they correspond to starting and ending segment coordinates. This is accomplished by sorting the coordinates with the integer sort routine SORTIN.

After a chromosome has been completely segmented, it must be removed from the image in order to prevent ROACH from re-encountering it while scanning the next line. The subroutine ERASE will use the segment coordinates to erase (set all 1-bits to zero) the chromosome from the image.

At this point, chromosomes may be accepted or rejected on the basis of length, width, area and perimeter measurements. All chromosomes thus accepted are recorded in an edge file, (see Flow Chart 5), in a format suitable for input to the phase SKIRT.

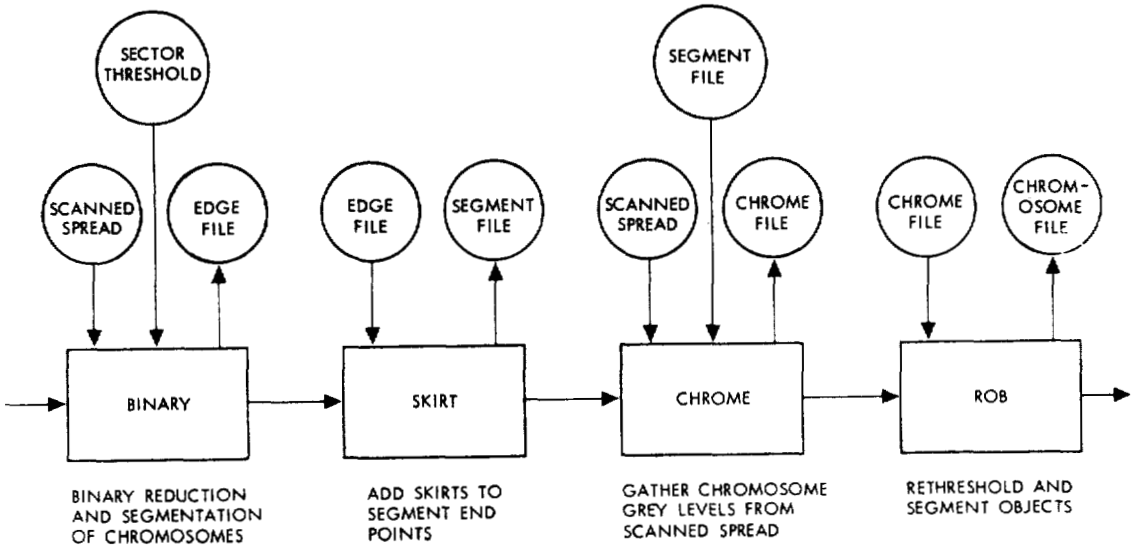
PARAMETERS: All parameters are optional and may appear in any order except where specified.

AREA followed by two integers representing the minimum and maximum allowable cross sectional areas.

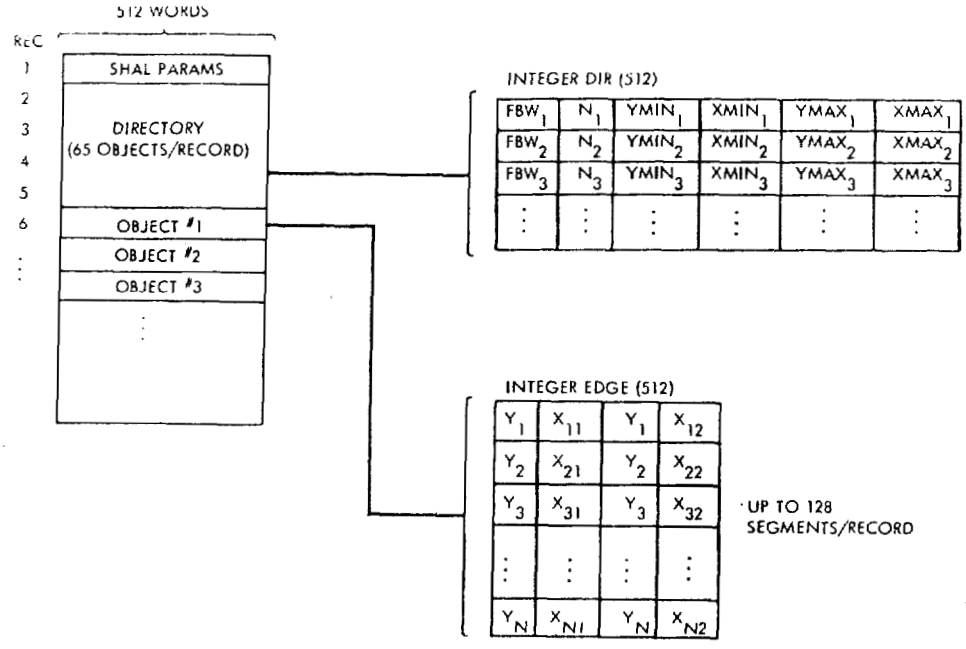
EP followed by two integers representing the minimum and maximum number of perimeter points allowable.

LENGTH followed by two integers representing the minimum and maximum allowable length.

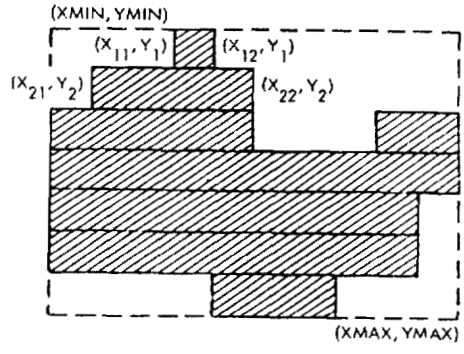
SKIRT followed by an integer representing the width of the skirt (in pixels) to be added to all the chromosomes during the SKIRT phase.



FLOW CHART 4 CALMS Segmentation Sequence



FBW = FIRST RECORD FOR OBJECT
N = NUMBER OF END POINTS



FLOW CHART 5 Edge File Format

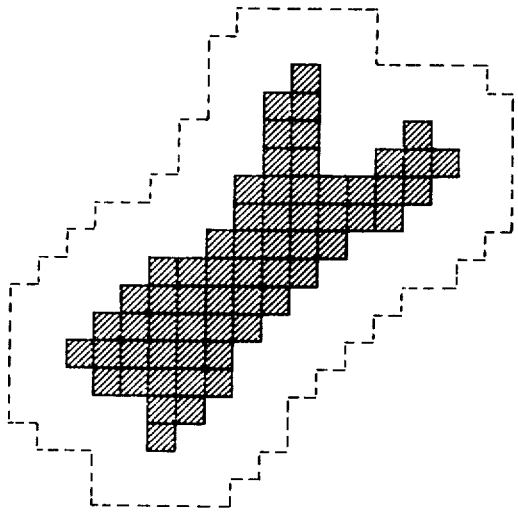
SKIRT

Purpose: To increase the cross sectional area of each segmented chromosome by recomputing the segment end points and storing the results in a segment file suitable for input to the CHROME phase.

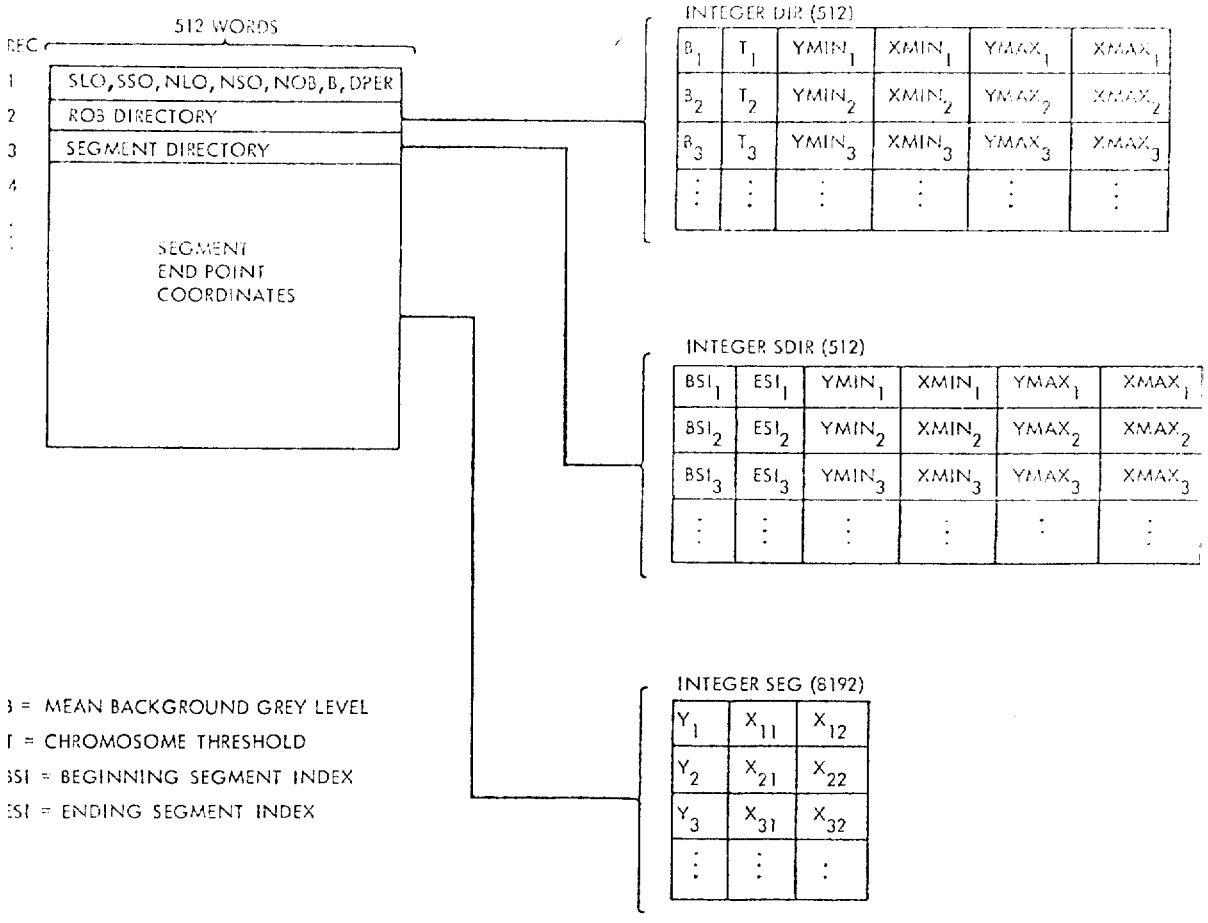
SKIRT will increase the area of each chromosome by extending its boundary outward a uniform distance in all directions. (Flow Chart 6.) Each chromosome is thus skirted with marginal elements to prevent loss of data when the boundaries are recomputed during the rethresholding step (ROB phase). SKIRT requires an edge file as input and generates a segment file. (See Flow Chart 7).

The width of the skirt is controlled by the parameter B (number of boundary samples), which is introduced in the BINARY phase. The chromosomes are enlarged by recomputing the segment end points, adding new segments where necessary and merging segments that have grown together. The segment end points are stored in the segment file as triplets (line coordinate and starting and ending sample coordinates).

The background gray levels and thresholds for each chromosome are computed by estimating its center of mass and interpolating over the values for the four nearest sectors.



FLOW CHART 6 Segmented Chromosome Surrounded by Skirt



FLOW CHART 7 Segment File Format

CHROME

Purpose: To gather the gray values of the segmented chromosome from the scanned spread and to store them in a chrome file.

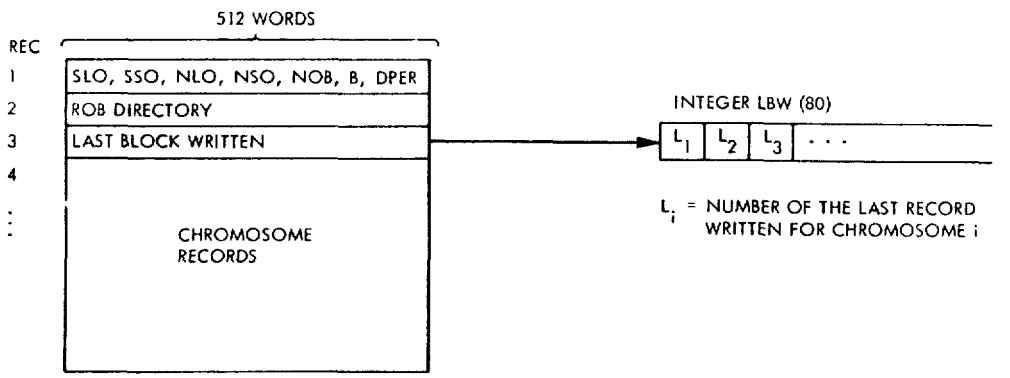
CHROME requires as input a scanned spread and its corresponding segment file. Using the segment end point coordinates, CHROME gathers the gray values for each chromosome and stores them in a chrome file in a format suitable for input to the ROB phase (Flow Chart 8).

In order to avoid re-reading scan lines, chromosomes which appear on the same line are processed concurrently. For this reason, the gray values are stored in an intermediate buffer (CBUF) until an entire chromosome has been processed or the buffer becomes full. When all the gray values for a chromosome have been gathered in CBUF, the gray values and their associated segment end point coordinates are assembled in one or more chromosome records (see Flow Chart 8) and written onto the chrome file. This task is performed by the subroutine WBUF. If the intermediate buffer becomes full, the chromosome occupying the most space in the buffer will be assembled and written out with a call to WBUF.

The intermediate buffer is partitioned into sections of a fixed size and formatted into a list structure to facilitate the allocation and release of buffer areas. The first word of each section contains the buffer index of the next section in the list (=0 for the last section in the list). The remaining words in each section is used to store gray level information.

Initially, all the sections are formatted into a single list representing all available sections. The next free section index (NFSI) points to the beginning of this list, and is updated whenever sections are removed from or added to the front of the list.

When sections are allocated to a chromosome, indexes pointing to the first and last sections of the chromosome list (FSI and LSI) are maintained in a chromosome directory.



EACH CHROMOSOME RECORD HAS THE FOLLOWING FORMAT:

PBW	NSEG	Y_1	X_1	N_1	$2N_1$ SAMPLES	$2N_1$ SAMPLES	Y_2	X_2	N_2	$2N_2$ SAMPLES	$2N_2$ SAMPLES . . .

WORD	
1	NUMBER OF THE PREVIOUS RECORD WRITTEN FOR THE CHROMOSOME (=0 FOR THE FIRST RECORD OF EACH CHROMOSOME)
2	NUMBER OF SEGMENTS IN THIS RECORD
3 AND 4	LINE AND SAMPLE COORDINATES FOR FIRST SEGMENT
5	NUMBER OF SAMPLE POINTS FOR FIRST SEGMENT (N_1)
6 TO $4N_1+5$	GREY LEVELS FOR FIRST SEGMENT. SINCE EACH SAMPLE POINT REPRESENTS A 2 X 2 PIXEL AREA, $4N_1$ PIXELS ARE STORED, OR $2N_1$ PIXELS EACH FROM TWO CONSECUTIVE LINES.
$4N_1+6$ TO ...	SIMILAR INFORMATION FOR THE SECOND SEGMENT

FLOW CHART 8 Chrome File Format

ROB

Purpose: To rethreshold and resegment the chromosomes and to store them in a chromosome file.

ROB requires as input a chrome file containing segment end point coordinates and gray level information for each chromosome. Each chromosome is reassembled in core and its histogram is generated. Based on its histogram, a new threshold is computed for the chromosome. Using this new threshold, the chromosomes are resegmented by applying algorithms very similar to those used in the BINARY phase, except that the algorithms are applied on the gray values themselves rather than on a binary reduction.

The segmentation process begins with a line by line scan for pixels above the computed threshold. This task is performed by the subroutine ISEG, which records the location of any objects that it finds. The task of tracking the perimeter of the object is performed by the subroutine SOT (Son of Turtle), which records the segment end point coordinates as it walks around the object on a counterclockwise direction. The coordinates are sorted to correspond to segment end points by the subroutine SORTIN.

The segments are examined for pixels lying within the original boundary for the chromosome established in the BINARY phase. If this search fails (i.e., if the object lies completely in the skirt), the object is rejected. This is necessary to prevent fragments of neighboring chromosomes from being included in the chromosome file.

The object is then assembled into one or more chromosome records and the space it occupied in core is zeroed out. The task of moving the object is performed by the subroutine REMOVE, which may optionally contrast stretch the gray values for maximal display. The object may be rejected at this point based on area measurements. The assembled chromosome records are written onto the chromosome file and the object entered into a chromosome directory.

The first record of the chromosome file contains the following:

WORD	
1	Number of chromosomes (maximum of 60)
2–241	Chromosome directory containing the following four numbers for each chromosome: FBW = First chromosome record written YMIN = Minimum line coordinate XMIN = Minimum sample coordinate LBW = Last chromosome record written
242–302	Thresholds used for each chromosome

The second record contains the following:

WORD	
1–60	Line coordinate of an internal point for each chromosome
61–120	Sample coordinate of an internal point
121–180	Perimeter measure for each chromosome

The remainder of the file is composed of one or more contiguous chromosomes records for each chromosome. Each such record will contain the following:

WORD	
1	Number of segments in this records
2	Line coordinate for first segment
3	Sample coordinate for first segment
4	Number of samples (N) in segment
5 to N+4	N Gray levels for this segment
N+5	Line coordinate for second segment
.	.
.	.
.	.

NOB

Purpose: To number the objects found by SEGMENT or ROB and display the picture on the gray scale.

NOB reads 122 words of parameters into NK, LT(60), ST(60), and FI. If FI is zero, NOB does not display the picture on the gray scale, and calls APHASE (MASKPH).

NK is the number of chromosomes and LT and ST are the lines and samples where the numbers are to be placed.

NOB reads one line at a time and adds any numbers required on that line. If LT is in order, NOB runs a little faster since it doesn't have to search the entire table for each line.

INT1

Purpose: To correct errors in object isolation.

INT1 is called immediately after each spread is scanned. The operator normally requests a quick count at this time. If the spread is only to be used for a count, the operator can correct for missing or extra objects and finish it.

If the spread is to be karyotyped, cuts, joins, and threshold changes are needed to correct for errors in object isolation. After the objects have been isolated, INT1 is called again to check for any remaining errors.

INT1 communicates with CALMS by calling APHASE. It writes parameters to BINARY to indicate a quick count, and to NOB to tell it to call MASK and not display the picture when finishing up a count.

MOB

Purpose: To orient and measure the chromosomes.

MOB orients each input object, accumulates IOD, area and length and calculates centromeric index by length, IOD and area. The unrotated chromosome file (UCR) is MOB's input (which is ROB's output) and the rotated chromosome file (RCR) is MOB's output. The format of RCR is as follows:

Rec. 1:	Word (1) = # of input objects (integer) Word (2,3) = Spread IOD (real) Word (4,5) = Spread length (real) Word (6,7) = Spread area (real) Word (8) = Next available record in RCR (integer) Word (9) = # of chromosomes Words (16–465) = Chromosome directory
Rec. 2:	Words (16–465) = Chromosome directory
Rec. 3:	Reserved for CLASFY results
Rec 4–7:	Reserver for BANDS results
Rec 8 &	following records: Rotated chromosome images

The chromosome directory (Rec 1 and Rec 2) has the following format:

Integer	CHDIR (15, 60) CHDIR (1,1) - CHDIR (15,30) on Rec 1 CHDIR (1,31) - CHDIR (15,60) on Rec 2

Each entry is as follows:

CHDIR	(1,I)	= 1st Rec. # of Ith rotated image, or zero if rejected
CHDIR	(2,I)	= # of lines in image
CHDIR	(3,I)	= # of samples in image
CHDIR	(4,I)	= Length of chromosome
CHDIR	(5,I)	= IOD/8 of chromosome
CHDIR	(6,I)	= Centromeric Index by Length
CHDIR	(7,I)	= Centromeric Index by Density
CHDIR	(8,I)	= Centromeric Index by Area
CHDIR	(9,I)	= Centromere line
CHDIR	(10,I)	= Perimeter of chromosome
CHDIR	(11,I)	= Area
CHDIR	(12,I)	= P^2/Area
CHDIR	(13,I)	=Centromere Location Method
CHDIR	(14,I)	= Available for expansion
CHDIR	(15,I)	= Available for expansion

MOB will reject objects if they are too large or too small. The maximum allowable size before rotation is 88 × 88. The maximum allowable size after rotation is 88 × 48. The maximum area is 2000 points, and minimum area is 30 points. The minimum length and width are 5 lines and 5 samples. When an object is rejected, its area, length, and width are typed.

Originally, MOB had an option to use a skeleton method in locating centromeres. However, this method took 25 sec. longer with little or no improvement in centromere accuracy. This option was removed in order to save core space and allow a larger maximum chromosome size.

CLASFY

Purpose: To classify the rotated chromosomes into **10** groups (conventional classifier).

CLASFY reads in the chromosome directory produced by MOB and classifies each object. Once classification is complete, CLASFY writes the classification tables into RCR, record **3**. The format is:

Word (1)	=	# of samples in karyogram
Word (2)	=	No object # flag
Word (3-12)	=	Group ID's
Words (13-102)	=	Slot ID's
Words (103-108)	=	Initial slot for each row
Words (109-199)	=	Object found in each slot
Words (200-204)	=	Center line table for each row
Words (205-294)	=	Center sample for each slot

This table is then used by KTYPE to build the output karyogram.

Classification is based on an internal table that gives the minimum and maximum allowable centromeric indexes for each length, for each of the ten groups of chromosomes. The table is called CT and is dimensioned (**20, 51**). The twenty entries for each length are minimum and maximum CI for **A-1, A-2, A-3**, B, C+X, D, **E-16, E-17** and **E-18**, F and G+Y.

First, an initial classification is made. Then, moves are made from "heavy" groups to "light" groups. When there are several candidates for a move, the one with "maximum likelihood" is chosen.

After all possible moves have been made, the chromosomes within each group are ordered according to the slope table which describes the slope of a line that sweeps in from the right. Most groups are ordered by size. When the C+X group has 15 or 16 members, the third largest or third and fourth largest are placed in the X slots. When G+Y has five members, the chromosome with the maximum fit factor is placed in the Y slot.

The classification table can be supplied to CLASFY with the OS parameter, followed by the object numbers for the slots. In this case, CLASFY sets up the karyotype format but does not do any classifications.

KTYPE

Purpose: Builds KARYOGRAM and displays it on the gray scale.

KTYPE utilizes the chromosome directory, the classification tables and the rotated images on RCR to build the karyogram on KGM.

IBUF is a 20480 byte buffer that holds one record for each object on the current line. Since the record length is **1024** bytes, twenty objects can be accommodated.

KTYPE builds the karyogram one line at a time, inserting line segments from IBUF, object numbers, centromere marks and slot ID's at the appropriate time in the appropriate place.

INT2

Purpose: Provide operator interaction to fix karyotype errors.

INT2 is called after the chromosomes have been measured, classified, and displayed as a karyotype. The operator can correct rotation errors, centromere errors, and classification errors. The corrections are normally done in the above order, since a rotation error usually causes a centromere error and a centromere error usually causes a classification error.

INT2 uses WPARAM to write parameters to MOB and CLASFY and uses RPARAM to read them back to see what has previously occurred. If the operator corrects rotation and centromere errors and does not move any chromosomes around, INT2 will allow CLASFY to reclassify on the basis of the new measurements. After the operator starts making moves, INT2 tells CLASFY what the karyotype should look like and does not allow an automatic reclassification.

RESEL

Purpose: Save information on measured chromosomes.

RESEL uses the MOB output to rearrange the measurements in order of type and store them in KDATA (BDATA for banded spreads). It also writes the patient report line in PDATA.

Format of KDATA: RECLEN = 1024

Line 1	Directory Record 1 for Source 1 spreads		
Bytes			
1-2	NEXT	1*2	Line # of next Dir Rec for Source 1, or 0
3-4	NUSED	1*2	# of spreads in this Dir Rec max is 85
5-854	PID (850)	BYTE	10 byte patient ID for each spread, or 0
855-1024	LINE (85)	1*2	Corresponding data line # for each spread
Line 2	Directory Record 1 for Source 2 spreads		
.			
.			
Line 15	Directory Record 1 for Source 15 spreads		

When "NUSED" becomes **85**, next available line # will be inserted into NEXT. Then the line in NEXT will be the next directory record for this source.

Line **16-500** Data Records and Directory Records, if necessary

Bytes			
1-64		LABEL 1	(First 64 bytes) source, patient, sex, slide, X,Y
65-84		LABEL 2	(First 20 bytes) scan time
85-104		LABEL 3	(First 20 bytes)scan ID
105-124		LABEL 4	(First 20 bytes) diagnosis
125-126	NC	I*2	# of chromosomes in the karyotype
127-128	LSUM	I*2	Length sum (not normalized for 46)
129-132	ISUM	REAL*4	IOD sum (not normalized for 46)
133-136	ASUM	REAL*4	Area sum (not normalized for 46)
137-144	UNUSED		
145-224	ON (80)	BYTE	Object #'s for types 1-24, 25-30, 31-40, or 0
225-304	ONL (80)	BYTE	# lines for each object
305-384	ONS (80)	BYTE	# samples
385-464	LEN (80)	BYTE	Length (adjusted for bend)-un-normalized)
465-624	IOD (80)	I*2	IOD/8 - unnormalized
625-784	AREA (80)	I*2	Area
785-864	CIL (80)	BYTE	CIL
865-944	CID (80)	BYTE	CID
945-1024	CIA (80)	BYTE	CIA
Records 2-4 for Banded Data			
1-1632	OCFOUR(51,8)	REAL*4	C for types 1-24,25,26
1633-3060	OPHI (51,7)	REAL*4	PHI for types 1-24, 25, 26
Negative Source = Banded spread and uses DK4:BDATA[6,6]			

MASK 2

Purpose: To combine two pictures and add a border.

MASK2 combines the numbered spread and karyotype into a single picture formatted for the hardcopy. The output is written on disk, with an option to also write it on tape if switch **5** is up.

The picture on disk is written in hardcopy format, with four bits for each element, and the picture on tape is written with eight bits for each element. Gray scales, reference masks and annotation are added to the picture.

MASK2 is also used to combine the numbered spread and the raw spread for counts. It checks for the KG parameter followed by the disk unit and filename for the raw spread.

MASK2 calls subroutines MSUB, WEDGE, REF, and WLINE to do the bulk of the work in creating the output picture.

BAND

Purpose: To find the waveform and calculate Fourier coefficients for banded chromosomes.

The input to BAND is the rotated chromosome file, RCR. For each chromosome, BAND first decides if the chromosome is straight or bent.

For bent chromosomes, BAND curve fits a parabola to the boundary points and recalculates the chromosome length. The waveform is determined by sampling along the parabola, and using three points perpendicular to the slope of the parabola.

For straight chromosomes, the waveform is determined by sampling along each line, using a moving window of eight points. The maximum value found along the line is used.

A and B Fourier coefficients are then computed from the waveform values for eight harmonics. From these, C (Amplitudes) and PHI (Phase Angle) are computed and saved in records **4-7** of the rotated chromosome file, RCR. Length and centromeric index are passed to FOUR as parameters.

BAND recognizes the following parameters:

WA: Store a representation of the waveform in place of the rotated chromosome images.

AX: Mark the axis for each chromosome

QB: Quick BAND — process only the C group.

FOUR

Purpose: To classify banded chromosomes using Fourier coefficients, length and centromeric index.

The inputs to FOUR are the classification table of means and variances, and the banded chromosome measurements. FOUR computes the likelihood that each chromosome belongs to each of the chromosome types, using 14 measurements — length, centromeric index by area, C(2) to C(8), and PHI (2) to PHI (6).

If a chromosome's length or centromeric index differs by more than 6 S.D. for a particular chromosome type, that type is ruled out for that chromosome. Similarly, if the C sum or PHI sum exceeds 7 S.D. or the total sum exceeds 8 S.D., that type is excluded for that chromosome.

The chromosomes are then classified in order of likelihood, subject to group membership rules. This procedure may leave some chromosomes unclassified, since certain types may have been excluded for certain chromosomes.

Using the unclassified chromosomes, the most likely classification is found, say chromosome *i* belongs to group *j*. The chromosomes in group *j* are then examined to see if one of them can be moved to another group that is not yet full. If so, the most likely move is made.

The classification results are written as parameters for CLASFY.

PREP

Purpose: To print the patient report

PREP reads the patient report records that were written on disk by RESEL, and prints them on the line printer. If the parameter PL is used, the records for differnet patients are separated by a double space. Otherwise, each patient's report is on a separate page.

ABNORM

Purpose: To print information on abnormal chromosomes ABNORM is called only when console switch **10** is down. It reads the rotated chromosome file, RCR, and examines the profile of each chromosome to determine centromere information. It then prints a message for each chromosome, regarding its normality.

KFIX

Purpose: Syntactical classification within B,D,F, and G groups.

KFIX is the final phase of the hybrid classifier for banded chromosomes, and operates as follows:

(1) Take the 4 chromosomes in the G group. Measure the position along the length of the chromosome of the brightest band. The 2 chromosomes with the bright band closest to the center correspond to the G-21 the other two are the G-22.

(2) Take the 6 chromosomes in the D group. Measure the ratio of average IOD in the upper half of the chromosome so that of the lower half of the chromosome. The two smallest values correspond to the D-13, the two largest values correspond to the D-15 and the remaining two are the B-14.

(3) Separate the F-19 and F-20 chromosome by IOD. The two chromosomes with the smallest integrated optical density are the F-19's.

(4) Take the B group. Measure the average IOD between the centromere position and a distance along the long arm equal to the short arm length or to the midpoint of the chromosome, whichever is shorter. The two chromosomes with the largest value correspond the B-4.

MVIO

Purpose: To read and write contiguous files with automatic double buffering, blocking, and random or sequential access to lines of data.

The calling sequences for the six entry points are as follows:

```
CALL OPEN (MVB,BUFSIZ(DBFLAG,-
  MODE,LNAME)
CALL GET (MVB,LINE,INDEX[,NORA])
CALL PUT (MVB,LINE,INDEX)
CALL CLOSE (MVB)
CALL READ (MVB,LINE,INDEX,LOC)
CALL WRITE (MVB,LINE,LOC)
```

An OPEN call is required before any GET or PUT calls can be made to a dataset. The user must provide core space large enough to hold all the necessary control blocks and control information, as well as the data that is to be read or written. This allows MVIO to be re-entrant. In addition, no space is wasted on unused data sets, as would happen if MVIO contained storage for a fixed number of data sets.

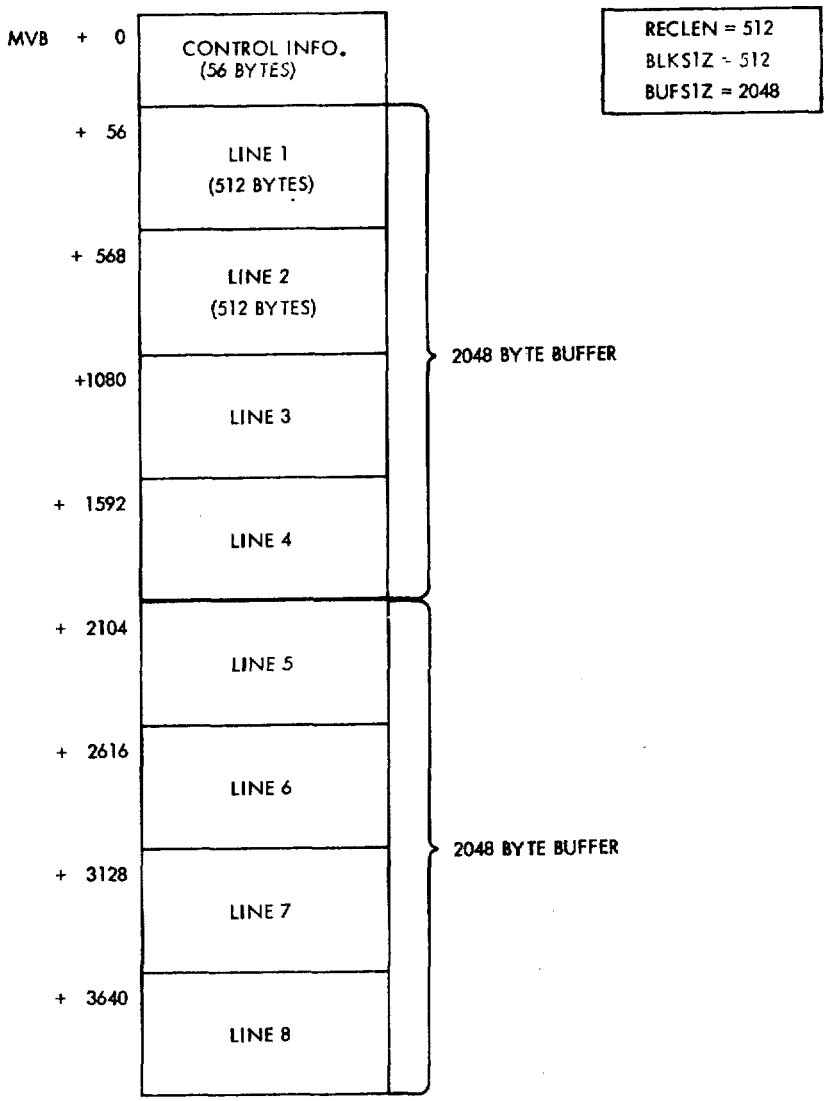
The control information can be considered as a "mini-VICAR-block" or MVB. Each MVB is 56 bytes long and contains a tran block, link block, filename block and the information required by MVIO. (See Flow Chart 9)

The MVB is followed by one or two buffers to hold the data that is read or written. Each buffer is a multiple of the RK11 disk block size (512 bytes). An entire buffer is normally read from or written onto the disk with a single access. This greatly increases the effective transfer rate. When two buffers are provided, MVIO allows the user to overlap computation with the disk input/output.

GET and PUT are called to obtain the index relative to the start of the MVB for the desired record in the data set. Thus the data does not have to be moved from one buffer to another. On most "get" calls, the requested line will already be in one of the buffers and MVIO simply returns the index without any physical I/O required.

PUT is called to obtain the index of where to store the line that is to be written. MVIO initiates physical I/O when a buffer has been completely filled. A "close" call is required to write any data left in a buffer by earlier "put" calls.

MV10 - BLOCKING AND DOUBLE BUFFERING EXAMPLE



FLOW CHART 9 MV10 - Blocking and Double Buffering Example

A logical record (or line) can be smaller than, larger than, or the same size as the physical block size (512 bytes). As previously noted, each buffer is a multiple of 512 bytes in length, but the buffer must also be large enough to hold a complete logical record.

MVIO (See Flow Chart 9) is normally used in conjunction with the label subroutines GLABEL and PLABEL, which are described in more detail elsewhere. They set up some of the fields in the MVB when the picture data is preceded by a label.

The fields in the calling sequences are defined as follows:

MVB is the location of the MVB for the data set. The user must reserve enough core for his buffers immediately following the MVB.

BUFSIZ is the size of each buffer (multiple of 512 bytes).

DBFLAG is the flag for double buffering, 0 = no double buffering (one buffer), 1 = double buffer (two buffers).

MODE is defined as:

0 = Disk Input	0,1 and 2 are functionally
1 = Disk Output	equivalent
2 = Disk Update	
4 = Tape Input	4, and 5 are functionally
5 = Tape Output	equivalent

LNAME is a three character logical name for the data set that can be used to assign it to a file with the $AS command. (Subroutine AFILE can be used to make a default assignment).

LINE is the desired line number, positive for data lines, negative for label records, and zero for the "next" line.

INDEX is the offset in bytes from the start of the MVB to the requested line. In Fortran, when MVB is defined as a byte array, sample J of the requested line is at MVB (J+INDEX). In Marco, MVB+INDEX is the location of the first sample of the requested line.

INDEX is set to zero for an end-of-file read from tape.

NORA is an optional parameter to prevent read-ahead.

READ and WRITE can be used when RECLEN = BUFSIZ and single buffering is specified. A line is read into LOC, or written from LOC, without any overlap.

Updating is normally done with a GET and a PUT for the record to be updated. (The same index value will be returned on the GET and PUT.) This insures that other records in the block and other blocks in the buffer will not be changed.

The "get" can be omitted only if all records are "put" sequentially, starting with the first record of a block.

The MVB format is shown below. Word numbers are in decimal, starting at 1 and byte numbers are in ocatl, starting at 0. TB = tran block, LB = link block, and FB = filename block.

WORD	BYTE		CONTENTS
1	0	TB	Active Block #
2	2	+2	Active Buffer Address
3	4	+4	Word Count
4	6	+6	Function/Status
5	10	+8	Words Not Transferred
6	12	IBN	Inactive Block #
7	14	IBA	Inactive Buffer Address
8	16	−2	Error Return
9	20	LB	Link Pointer
10	22	+2	Logical Name
11	24	+4	Unit #! Words To Follow
12	26	+6	Device Name
13	30	CRC	Current Record #
14	32	−2	Indicator ! Unused
15	34	FB	File Name (Word 1)
16	36	+2	File Name (Word 2)
17	40	+4	Extension
18	42	+6	UIC
19	44	WNT	Words Not Transferred
20	46	SBN	Start Block #
21	50	NBF	# Blocks In The File
22	52	NLR	# Label Records
23	54	RECLEN	Record Length (Multiple or Divisor of BLKSIZ)
24	56	BLKSIZ	Block Size
25	60	BUFSIZ	Buffer Size (Multiple of BLKSIZ and RECLEN)
26	62	BPB	Blocks Per Buffer
27	64	DBF/MD	Mode ! Double Buffering Flag
28	66	WFLAG	Write Flag (Last Block # To Be Written + 1)

LABEL

Callable Entry Point Names: GLABEL, PLABEL

Purpose: To obtain and store label information on disk data sets.

These subroutines are used in conjunction with MVIO, when processing labeled data sets. They obtain or store the label parameters, and also set up the BLKSIZ, RECLEN, NLR, and BPB fields in the MVB. GLABEL and PLABEL must be called after the OPEN call for the MVB.

CALL GLABEL (MVB, SPAR, INDEX) to get a label

CALL PLABEL (MVB,SPAR,LABEL) to put a label

MVB is the mini-VICAR block for the data set.

SPAR is a five word table of system parameters

SPAR (1) = NL, # Lines of picture data

SPAR (2) = BPL, Bytes per line

SPAR (3) = BPE, Bits per element

SPAR (4) = NLR, # of label records

SPAR (5) = BLKSIZ, Block size

GLABEL transfers the label information into SPAR.

PLABEL transfers the data in SPAR to the label.

Index is the offset from MVB to the first byte of the label, as returned by 'get.'

Label is the location of the label to be output.

Example:

```
INTEGER SPAR (5)
BYTE A (4200), B (4200)
CALL OPEN (A,2048,1,0,'MV1')          Open A for input
CALL OPEN (B,2048,1,1,'MV2')          Open B for output
CALL GLABEL (A,SPAR,IA)               Get label from A
CALL PLABEL (B,SPAR,A(IA+1))          Put label to B
```

GLABEL can also be used with an unlabeled data set. It will return NL as the # blocks in the data set

BPL = 512

BPE = 8

NLR = 0

These routines are re-entrant, except when GLABEL is used with an unlabeled data set.

EXIT

Purpose: To replace the FORTRAN exit and error subroutines and save 1260 bytes of core.

EXIT can be used to save core after a FORTRAN program has been checked out. ERRA gives a single error message (A367), instead of the individual messages normally given by the FORTRAN error routine ERRA.

When EXIT is called, it will either return to DOS via a .EXIT or return to CALMS via an RTS R5. It makes this decision by checking the value of R5 when EXIT was called. When DOS loads a program, it clears R5, but when CALMS loads a program, R5 is equal to a location within CALMS.

Therefore, CALL EXIT will work for programs running under DOS or under CALMS.

In order to select EXIT.OBJ over the FORTRAN exit subroutine, specify EXIT before FTNLIB in the link command string. The /SU switch should be used in the FORTRAN command string to save additional core and time.

All FORTRAN modules of CALMS should be compiled with /SU or they may not fit in core.

SAVER

Purpose: To save and restore registers 0–4 on the stack, for subroutines called with an R5 calling sequence.

SAVER and RESTR provide a convenient way for MACRO subroutines to save and restore registers 0–4 on the stack.

To save registers 0–4:

JSR R4, SAVER

To restore registers 0–4 and return via R5:

JMP RESTR

(SAVER is called via R4, and R5 is not saved.)

AFILE

Purpose: To assign a file to a dataset.

CALL AFILE (MVB, DUNIT, FILPEX, GRP, USR)

MVB is the mini-VICAR block for the dataset.

DUNIT is the disk unit (1 for DK1:, 2 for DK2:, etc.)

FILPEX is the 6 character filename plus 3 character extension.

GRP is the group number from the UIC

USR is the user number from the UIC.

Example:

CALL ALFILE (A,1, 'PIC ', 5,5)

Assigns DK1:PIC[5,5] to MVB A

PARAM

Callable Entry Point Names: PARAM, PARBUF

Purpose: To read free-field parameters from the keyboard and convert them.

PARAM types an *, then reads up to 80 characters from the keyboard, terminated by a carriage return. Parameters are separated by blanks or commas, and can be one of the following:

1. One word integer — negative integers are preceded by a minus sign.

2. Two word alphameric — first character must be alphabetic. The character string is padded with trailing blanks if less than 4 characters. It is truncated if more than 4 characters.

3. Variable length alphameric — the string is enclosed in apostrophes. If an odd number of characters, the last word is padded with a trailing blank. If an apostrophe is desired, type two consecutive apostrophes.

The raw character string is saved at 'PARBUF' which is accessible to MACRO programs, but not FORTRAN. However, the user can optionally supply his own PARBUF.

The calling sequence is:

CALL PARAM (N,P PAR, MAXNP [,PARBUF])

NP is the number of parameter words that were stored in PAR

MAXNP is the maximum allowable number of parameter words (the size of PAR)

PARBUF is optional 83 byte user buffer for the raw character string.

Example:

INTEGER PAR (20)

CALL PARAM (NP, PAR, 20)

If the user types:

NH, PRINT, 42, −1, 'ABC' 'DEF'

The result is:

PAR (1) = NH
PAR (2) = AA
PAR (3) = PR
PAR (4) = IN
PAR (5) = 42
PAR (6) = −1
PAR (7) = AB
PAR (8) = C'
PAR (9) = DE
PAR (10) = FA
NP = 10

PARAM is reentrant if the user supplies PARBUF. However, an earlier keyboard input request must be satisfied before a latera one can be done.

PARAM maintains a byte with the global name 'PBUSY'. It is set to one when PARAM is entered, and cleared when PARAM exits.

Any program which is entered by an interrupt (such as SEARCH or HCOPY) must check that PBUSY = 0 before calling PARAM. If PBUSY is not zero, the program must signal PARAM that it is waiting to call it, but could not because PARAM was busy. It does this by storing the location for PARAM to transfer control to in 'PINT' or PINT+2, and then executing an RT1.

PARAM will then call the waiting routine with a simulated interrupt, when it has finished with the earlier request.

(The PBUSY, PINT method is required under DOS; otherwise the KB driver gets confused).

QPRINT

Purpose: To print a message, with automatic buffering

QPRINT waits for completion of a previous print, moves the message to its own buffer, initiates a print with a TRAN request, and returns to the user.

CALL QPRINT (LOC[,NBYTES])

LOC is the first byte to be printed (carriage control). NBYTES is the number of bytes to be printed. (maximum — 132).

NBYTES can be omitted if the message is terminated with a "zero" byte.

FORTRAN automatically inserts a zero byte for literal strings and 'ASCIZ', in MACRO, also does this.

Example:

CALL QPRINT ('single space')
CALL QPRINT ('0 double space')

TYPE

Purpose: To type a message with automatic buffering

TYPE is similar to QPRINT, except that output is on the keyboard and the maximum message length is 80 bytes.

CALL TYPE (LOC [,NBYTES])

If NBYTES is omitted or zero, a null (0) terminates the message. TYPE inserts a <CR> at the end of the message unless NBYTES = 0.

IV

Purpose: To convert and move logical *1 (byte) data and word data

IV is a function and the other entry points are subroutines. These routines consider bytes to be positive numbers from 0–255. (FORTRAN treats bytes as signed numbers from −128 to +127.)

IV (byte) = Integer value (0-255) of a byte variable
CALL ITL (INT, L1) (INTEGER TO LOGICAL)
Move the low order byte of INT to L1.
CALL MVL(L1, L2, N) (Move LOGICAL)
Move N bytes starting at L1 to L2
CALL MVW (I1, I2, N) (Move WORD)
Move N WORDS starting at I1 to I2
CALL ZIA (IBUF,N) (Zero INTEGER array)
Zero N WORDS starting at IBUF
CALL ITLA (INT,L1,N) (INTEGER to LOGICAL array)
Store INT in N bytes starting at L1
CALL SWAP (I1, I2)
Interchange I1 and I2.
Note: RO is not saved by these routines!

TEXT

Purpose: To generate readable characters for labeling of pictorial output.

Each character is generated from a six sample by seven line array of BIT, where a one BIT represents black and a zero bit represents white. The left most of the six samples is always zero.

CALL TEXT(INBUF, INCHR, LINE, OUTBUF, SIZE)

INBUF is the location of the input ASCII characters

INCHR is the # of input characters

LINE is the line number (0-6) of the bit array

OUTBUF is the location for the output bytes

SIZE is the number of bytes to store for each bit (1,2, . . .)

OUTBUF must be at least INCHR*SIZE*6 bytes long

HCPAK

Purpose: To pack and unpack data in hardcopy format (4 bits) and convert from 7 to 8 bit format.

CALL HCPAK (BUF8, BUF4, NE)

CALL HCUPK (BUF4, BUF8, NE)

CALL MVW78 (BUF7, BUF8, NW)

BUF8 is the LOC of 8-Bit Data

BUF4 is the LOC of 4-Bit Data

BUF7 is the LOC of 7-Bit Data

NE is the number of elements to pack or unpack. NW is the number of works to convert from 7-Bit format to 8-Bit format.

RPARAM

Purpose: To pass parameters to a CALMS phase and to assign the next phase to be loaded.

CALL WPARAM (NP, PAR, PNUM)

NP is the number of words of parameters to write

PAR is the location of the parameters

PNUM is the number of the phase which is to receive the parameters

CALL RPARAM (NP, PAR, NPMAX [,PNUM])

To read parameters through the CALMS supervisor. See the PARAM writeup for details. PNUM is an optional phase nunber used to read another phase's parameters.

CALL APHASE (N)

Normally, phases are loaded in sequence, but APHASE is used to change the sequence.

N is the number of the phase.

DLINE

Purpose: Subroutines used to access the gray scale and cursor, when running under the CALMS supervisor.

CALL DECLEAR to erase the entire gray scale.

CALL DLINE (LOC,Y,X,NS,REPL,ERASE) to write a line of data.

LOC is location of data in core.

Y is line on gray scale (**0-1023**)

X is starting sample on gray scale (**0-1023**)

NS is number of samples

REPL is non-zero to replicate samples and lines. (If switch 3 is up, only samples are replicated)

ERASE is

positive to erase this line before writing

negative to erase only

zero to write only.

CALL DWAIT to wait for gray scale ready

CALL CURSOR (Y,X,LINE,SAMP) to read the cursor.

Y is the line on the gray scale (**0-1023**)

X is the sample on the gray scale (**0-1023**)

LINE is the picture line (**1-512**)

SAMP is the picture sample (**1-512**)

CALL SC sets up the cursor adjustments and saves them on disk as parameters for INT1.

CALL RCA reads in the cursor adjustments from disk.

CALL MCU moves the cursor up one line

CALL MCD moves the cursor down one line

CALL MCL moves the cursor left one sample

CALL MCR moves the cursor right one sample

CALL UDLR (PAR) moves the cursor one step according to whether PAR is a U,D,L, or R.

The cursor adjusment process is required to correct for cursor drift. Two marks are written on the gray scale, one at **32, 32** and one at **992, 992**. The operator is requested to move the cursor to these reference positions and the readings are saved. Thereafter, CURSOR performs a linear interpolation on all cursor readings, using the saved values.

There is also a standalone version of DLINE in FTNLIB. It differs from the CALMS version in the way the cursor adjustments are saved and read back.

MCISUB

Purpose: Subroutines to control the MCI and sort the spread queue.

This module consists of miscellaneous subroutines used by SEARCH and CALMS. It also globally defines the MCI register addresses and interrupt vector locations.

CALL IXYABS (Y,Y) Initiates a motor move to X,Y

CALL IXREL (XDEL) Initiates a relative X move

CALL IYREL (YDEL) Initiates a relative Y move

CALL IFREL (FDEL) Initiates a relative F move

CALL CFOC (F) Stores the sum of the two focus parameters

CALL LED (CODE,VAL) Puts VAL in the LED whose code is given

CALL MFST (MAGN, FPOS) Stores the magnification and filter position in MAGN and EPOS, and displays the magnification in the magnification LED. It also stores FSTEP, FLAST, XADJ, and YADJ for the lens in use.

CALL SORTQ Sorts the spread queue according to its rating.

ROACH

FUNCTION: ROACH (WI,BI,WORD,EWI,-MASK)

ROACH will scan a binary line to locate the first set bit. The scan will begin at WORD (WI) and end at WORD (EWI). If no set bit is found, the return code is zero. If a set bit is found, WI is returned as the index of the word containing the bit. BI is the bit index within the word (numbered 0, 1, 2, . . . , 15). The corresponding bit position within the MASK is also set.

TURTLE

TURTLE is invoked by SEGMENT to walk counterclockwise around the perimeter of objects in the binary picture.

CALL TURTLE (COMMON,EDGE,WOD,-MASK,NW2)

COMMON is composed of the following six words:

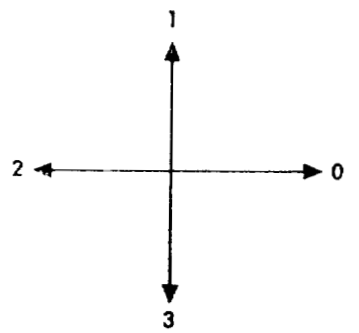
N = the number of segment end points found

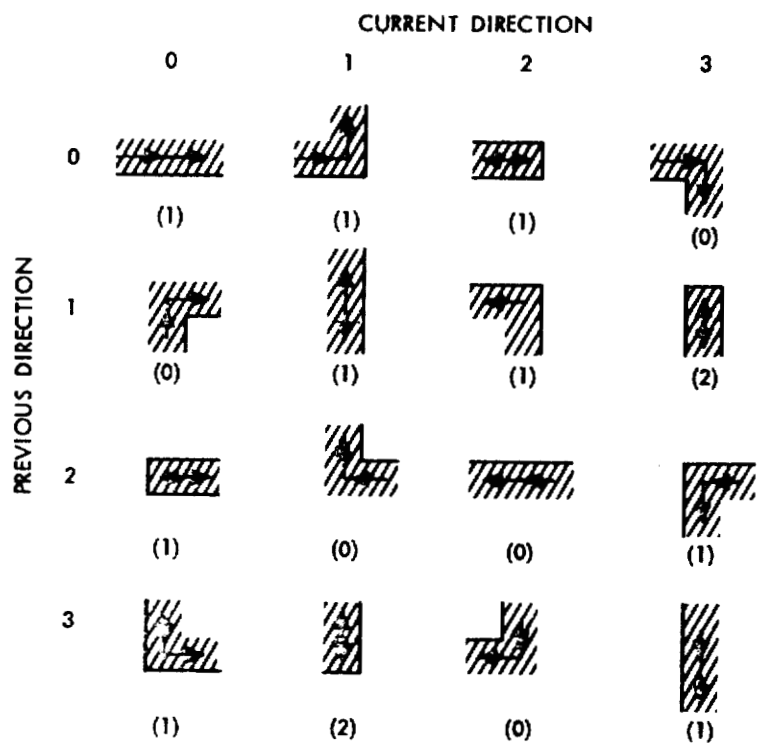
PERIM = the number of perimeter points found
YMIN,XMIN, YMAX,XMAX, = the extreme coordinates of the object

EDGE is an integer array into which is placed the coordinates of the detected end points. On input, WORD points to the word containing the first detected bit of the object and MASK designates the bit positions within that word. NW2 is the number of bytes per line.

The TURTLE uses a four point connectivity algorithm in walking around the perimeter. At each step, the TURTLE will examine its four adjacent neighbors, numbered 0,1,2, and 3 (See Flow Chart 10) to determine its new direction. The order in which neighboring samples are examined is predetermined to ensure that the TURTLE will always proceed in a counterclockwise direction (See Flow Chart 11).

Since not all perimeter points are segment end points, the TURTLE uses a decision table to identify the end points. End point determination is based on the TURTLE's previous and current directions, and his conviction that since he is traversing the perimeterin a counterclockwise direction, the chromosome will always remain on his left. Line segments which contain only one sample are recorded twice so that all segments have starting and ending end point coordinates. The TURTLE's decision table is given in Flow Chart 10. The number of times perimeter points are recorded as end point coordinates appears in parentheses.





SEGMENT END POINT DECISION TABLE

FLOW CHART 10 Segment and Point Decision Table

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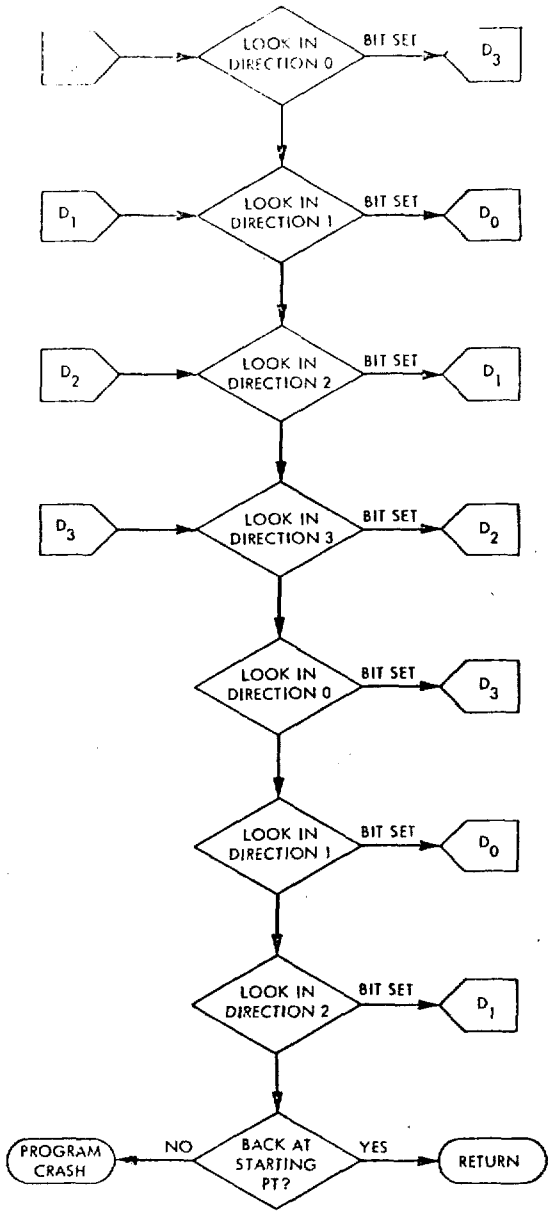

FLOW CHART 11 Four Point Connectivity Algorithm

SORTIN

SORTIN is invoked by SEGMENT to sort the end point coordinates for a chromosome in the order that they would be encountered while scanning the chromosome line-by-line from left to right. Thus, the short is in assending order, first by line coordinate, and second by sample coordinate.

CALL SORTIN(EDGE,N,IND)

N is the number of end points.

Upon return, IND=0 if the sort was successful, $\neq 0$ if not.

EDGE is a buffer area 4N words long. The first 2N words contain the end point coordinates for the chromosome. The remaining 2N words is used as a work area for the bucket sort routine.

SORTIN uses a byte array to keep track of the ordering of the end points. Because of this, a maximum of 255 end points may be sorted.

ERASE

ERASE is invoked by SEGMENT to remove a chromosome from the binary spread image.

CALL ERASE(WORD,EDGE,AREA,N2,NW)

WORD points to the buffer area containing the binary image.

EDGE points to the end point coordinates for the chromosome.

N2 is the number of coordinates in EDGE (two per coordinate pair).

NW is the number of words per line in the binary image.

AREA is returned as the number of sample points contained in the chromosome.

ORIOB

Purpose: Orient objects.
CALL ORIOB(IBUF,OBUF,EF,CHDIR,NL,O-PROT,RCODE)
ORIOB finds the minimum enclosing rectangle for the object in IBUF using the endpoint table EP and 32 rotations from 0° to 90°. It then rotates the object into OBUF and sets the rotated NL and NS in CHDIR. OPROT specifies any additional rotation desired by the operator.

EPROT

Purpose: Rotates chromosome endpoints.
CALL EPROT(SIN,COS,NL,EP,XMIN,XMAX-,YMIN,YMAX)
EPROT rotates the endpoints (EP) by the angle specified by SIN and COS. It returns the limits of the enclosing rectangle (XMIN,XMAX, YMIN,YMZX).

OBROT

Purpose: To rotate objects.
CALL OBROT(XMIN,XMAX,YMIN,YMAX,-COS,SIN,IBUF,OBUF)
OBROT rotates the object in IBUF into OBUF. COS and SIN specify the rotation angle and XMIN,X-MAX,YMIN,YMAX give the enclosing rectangle of the object in unrotated coordinates.

Four point linear interpolation is used to set the intensity values of the rotated object.

ACCSUB

Purpose: Accumulate area and density by sample for rotated object.
CALL ACCSUB(BUF,NL,MS,AREAA,DENA,-TAREA,TDEN)
The chromosome is located in BUF and is NL by NS. AREAA is the area accumulator by sample and DENA is the density by sample. TAREA and TDEN are the area and density totals for the object.

CHROUT

Purpose: To stand objects up and move them into the output buffer.
CALL CHROUT(IBUF,OBUF,NS,NL,LP-B,IP,FLG,BUFSZ)
CHROUT rotates the object in IBUF (NS X NL) by ± 90° in to OBUF for output. LPB gives # of lines that will fit into OBUF, FLG tell which way to rotate object and BUFSZ is NS for IBUF.

KURSOR

Purpose: To locate information about the karyogram for the current cursor position.
CALL KURSO R(Y,X,L,S,SLID,SLCL,SLCS,N)
Y,X,L,S are the cursor coordinates returned by cursor. SLID is the slot ID indicated; SLCL and SLCS are the slot center coordinates; and N is the object ID of the object residing in the slot.

COMPUTER PRINTOUT PROG 1

```
        .TITLE  CALMS - CALMS SUPERVISOR
        .NLIST  BEX
        .MCALL  .CALL,.EXIT,.PAUSE,.INIT,.TRAN,.WAIT,.RLSE
        .GLOBL  RLS.,CVT.,CDT.   ;MAKE EMTS RESIDENT
;SUPERVISOR FOR THE CLINICAL AUTOMATED LIGHT MICROSCOPE SYSTEM
;FOR CHROMOSOME ANALYSIS.
;THE SUPERVISOR CONTROLS SLIDE SEARCH, SCANNING, ANALYSIS, AND HARD-COPY
;OUTPUT OF KARYOTYPES OR COUNTS.
;SEARCH AND HARD-COPY ARE PERMANENTLY RESIDENT BELOW LOCATION 60000.
;SCAN AND ANALYSIS CONSISTS OF 16 PHASES THAT RESIDE ON DISK IN CORE-
;IMAGE FORMAT.  ONE PHASE AT A TIME IS LOADED AT LOCATION 60000 AND
;CALLED BY THE SUPERVISOR.

        LF=12                   ;LINE FEED
        PSW=177776
        NPH=24.                 ;# OF PHASES
        BINPH=2                 ;BINARY PHASE NUMBER
        NOBPH=6                 ;NOB PHASE NUMBER
        INTPH=7                 ;INTI PHASE NUMBER
        MOBPH=8.                ;MOB PHASE NUMBER
        MASKPH=13.              ;MASK PHASE NUMBER
        NSDS=3                  ;# OF SCAN DATA SETS
        NHDS=2                  ;# OF HARDCOPY DATA SETS
        SDU=5                   ;SCAN DISK UNIT
        HDU=3                   ;HARDCOPY DISK UNIT
        MVBSIZ=56.
        LABSIZ=12.
        IBN=12                  ;MVB DEFINITIONS
        IBA=14
        CURREC=30
        SBN=46
        RECLEN=54
        BUFSIZ=60
        BPB=62
        DBFLAG=64
        SWR =177570
```

```
; CURRENT ORIGIN IS 30000
SOURCE: .WORD   8.
NSCAN:  .WORD   0               ;# TO BE SCANNED
PNUM:   .WORD   -.              ;CURRENT PHASE NUMBER
PANUM:  .ASCII  /12345678 /     ;PATIENT IDENTIFICATION
SLNUM:  .ASCII  /123A1    /     ;SLIDE IDENTIFICATION
PASEX:  .ASCII  /F /            ;PATIENT SEX
SPN:    .WORD   -.              ;CURRENT SPREAD NUMBER
CSPQ:   .WORD   SPQ+.-.         ;CURRENT LOC IN SPQ
SPR:    .BLKB   300.            ;SPREAD RATINGS
SPQ:    .BLKW   600.            ;SPREAD QUEUE (X,Y)
LPANUM: .WORD   10.             ;LENGTH OF PANUM IN BYTES
LSLNUM: .WORD   8.              ;LENGTH OF SLNUM
NPHASE: .WORD   -.              ;NEXT PHASE TO BE CALLED
        .PAGE
CALMS:  .CALL   TYPE,<MSG2,ZERO>        ;ASK ABOUT RESTART
        MOV     #6,R1
        CLR     LINE
CLED:   .CALL   LED,<LINE,ZERO> ;INITIALIZE LEDS
        INC     LINE
        SOB     R1,CLED
        .CALL   OPEN,<MYB,PSIZE,ZERO,ZERO,LNAM> ;OPEN OVERLAY DATASET
        MOV     PSIZE,MYB+RECLEN
        .CALL   OPEN,<PMYB,PARSIZ,ZERO,TWO,PLNAM>       ;PARAMETER DS
        MOV     PARSIZ,PMYB+RECLEN
        MOV     #4,DNPTAB+INTPH+INTPH-2 ;SET TO READ 4 CURSOR ADJMNTS
        MOV     #512.,NPTAB     ;ALLOW RESTART
        MOV     #512.,DNPTAB
        MOV     #NHDS,R0        ;SET UP THE START BLOCK NUMBERS FOR
        MOV     #HSBN,R1        ;ALL HARDCOPY DATA SETS
C05:    MOVB    R0,FILPEX+1
        BISB    #60,FILPEX+1    ;CONVERT TO ASCII
        .CALL   APILE,<A,LHDU,FILPEX,TWO,TWO>
        .CALL   OPEN,<A,TWELVE,ZERO,ZERO,LNAME>
        MOV     A+SBN,(R1)+     ;SAVE THE START BLOCK NUMBER
        SOB     R0,C05
        .CALL   SEARCH          ;INITIAL CALL TO SEARCH
        JSR     PC,PPAR         ;PROCESS RESTART AND PHASE PARAMETERS
        TST     NSCAN
        BNE     S10             ;BR IF A SCAN RESTART
S06:    JSR     PC,TNSCAN       ;IF NSCAN=0 , ALLOW SEARCH START
;
S10:    TSTB    SFLAG           ;'IDLE LOOP' STARTS HERE
        BNE     S40             ;BR IF SEARCH RUNNING
        TST     NSCAN
        BEQ     S40             ;BR IF NONE TO SCAN
S13:    MOV     #NSDS,R0        ;LOOK FOR SCAN DS
S15:    MOV     #SDS,R1
        MOV     NFSDS,R2        ;# FULL SCAN DATASETS
        BEQ     S22             ;BR IF ZERO
S20:    CMPB    R0,(R1)+        ;CHECK R0 AGAINST ALL FULL DATASETS
        BEQ     S25             ;BR IF DATASET IS IN USE
        SOB     R2,S20          ;BR IF MORE TO CHECK
S22:    MOVB    R0,@R1          ;OK TO USE THIS DATASET, STORE IT
        BR      S30             ;GO CALL SCAN
S25:    SOB     R0,S15          ;BR IF MORE TO TEST
        BR      S40             ;NONE AVAILABLE
S30:    BIS     #60,R0          ;CONVERT TO ASCII
        MOVB    R0,FILPEX+1     ;STORE IN FILENAME
        MOVB    #'S,FILPEX      ;AS SN
        MOV     #SDU,DUNIT      ;STORE SCAN DISK UNIT
        DEC     NSCAN           ;NSCAN=NSCAN-1
S31:    .CALL   PHASE,<ONE>     ;SCAN
        .CALL   LED,<SQLED,NSCAN>
        TST     NPHASE
        BEQ     S06             ;BR IF SCAN WAS ABORTED
        CLR     NPTAB+NOBPH+NOBPH-2     ;CLEAR NOB PARAMETERS FOR INT1
S315:   CLR     NPTAB+BINPH+BINPH-2     ;CLEAR BINARY PARAMETERS
        .CALL   PHASE,LINTPH    ;CALL INT1 FOR THE PRE-FOB ADL
        CMP     NPHASE,#1       ;TEST FOR RESCAN OR ABORT
        BEQ     S31             ;BR IF RESCAN
        BLT     S06             ;BR IF SPREAD WAS ABORTED IN INT1
        CMP     NPHASE,#NOBPH
        BNE     S33             ;BR IF NOT A COUNT
        .CALL   PHASE,NPHASE    ;CALL NOB
```

```
        CMP     NPHASE,#MASKPH
        BNE     S315            ;BR IF NOT MASK
S32:    JSR     PC,TNSCAN       ;IF NSCAN = 0 , ALLOW SEARCH START
        JMP     C15             ;GO CALL MASK2
S33:    CMP     NPHASE,#MASKPH
        BEQ     S32             ;BR IF MASK
        TST     NPTAB+BINPH+BINPH-2
        BEQ     S38             ;BR IF NOT QUICK OPTION
        .CALL   PHASE,NPHASE    ;CALL BINARY
        BR      S315
S38:    INC     NFSDS           ;INCREMENT ANALYSIS QUEUE
        .CALL   LED,<AQLED,NFSDS>       ;UPDATE ANALYSIS QUEUE
        BR      S06
S40:    TSTB    PFLAG           ;SEE IF PATIENT REPORT WAS REQUESTED
        BEQ     S42             ;BR IF NOT
        CLRB    PFLAG
        .CALL   PHASE,PPHASE    ;CALL THE PATIENT REPORTER
S42:    TSTB    EFLAG           ;SEE IF TEXT EDITOR WAS REQUESTED
        BEQ     S45             ;BR IF NOT
        CLRB    EFLAG
        .CALL   PHASE,EPHASE    ;CALL THE EDITOR
S45:    TSTB    FRFLAG          ;SEE IF FORTRN WAS REQUESTED
        BEQ     S46             ;BR IF NOT
        CLRB    FRFLAG
        .CALL   PHASE,FPHASE    ;CALL FORTRN
S46:    TSTB    RFLAG           ;SEE IF RESTART WAS REQUESTED
        BEQ     S47             ;BR IF NOT
        CLRB    RFLAG
        JSR     PC,RSTRT
        BR      JPS10           ;GO BACK FOR RESTART
S47:    MOV     #SDS,R1         ;SEE IF READY FOR ANALYSIS
        MOV     NFSDS,R2
        BEQ     JPS10           ;BR IF NO FULL SCAN DATASETS
        MOVB    #'S,FILPEX
        MOV     #SDU,DUNIT
        MOVB    @R1,FILPEX+1
        MOVB    @R1,R0          ;SAVE DATA SET # IN R0
        BISB    #60,FILPEX+1    ;CONVERT TO ASCII
        DEC     NFSDS
        DEC     R2
        BEQ     S60             ;BR IF NO DATASET NUMBERS TO MOVE
S50:    MOVB    1(R1),@R1       ;MOVE DATASET NUMBERS TO TOP OF LIST
        INC     R1
        SOB     R2,S50
S60:    MOV     FPHASE,NPHASE   ;START ANALYSIS WITH PHASE 2 OR DEBUG PHASE
        MOV     #DNPTAB,R0
        MOV     #NPTAB,R1
        MOV     #NPH,R2
S65:    MOV     (R0)+,(R1)+     ;MOVE DNPTAB TO NPTAB
        SOB     R2,S65
                                ;ANALYSIS LOOP STARTS HERE
S75:    .CALL   PHASE,<NPHASE>  ;CALL AN ANALYSIS PHASE
        TSTB    RFLAG           ;TEST RESTART FLAG
        BEQ     S80             ;BR IF NOT SET
        CLRB    RFLAG
        JSR     PC,RSTRT
S80:    TST     NPHASE          ;TEST FOR ABORT (OR ANALYSIS RESTART)
        BNE     S85             ;BR IF NOT AN ABORT (NPHASE=0)
        .CALL   LED,<AQLED,NFSDS>
JPS10   JMP     S10
S85:    CMP     NPHASE,#MASKPH
        BNE     S75             ;BR IF NOT THE MASK PHASE
                                ;END OF ANALYSIS LOOP
                                ;LOOK FOR HARDCOPY DATA SET
C15:    MOV     #NHDS,R0        ;# HCOPY DATA SETS
        MOV     #HDS,R1
        MOV     #HSBN,R2
C20:    TSTB    (R1)+
        BEQ     C30             ;BR IF DATASET IS EMPTY
        TST     (R2)+           ;STEP HSBN
        SOB     R0,C20          ;BR IF MORE TO TEST
        BR      C15             ;NONE AVAILABLE, KEEP LOOKING
C30:    BIS     #60,R0          ;CONVERT TO ASCII
        MOVB    R0,FILPEX+1     ;STORE IN FILENAME
```

```
        MOVB    #'H,FILPEX          ;AS HN
        MOV     #HDU,DUNIT          ;HARDCOPY DISK UNIT
        INCB    -(R1)               ;SET DATASET BUSY
        MOV     R1,CMDS             ;SAVE LOC OF CURRENT MASK DATASET
        MOV     R2,CSBN             ;SAVE SBN LOCATION
        .CALL   PHASE,<MPHASE>      ;MASK2
        MOVB    #-1,@CMDS           ;SET DATASET FULL OF DATA
        INC     NHCOPY
        .CALL   LED,<HQLED,NHCOPY>
        .CALL   LED,<AQLED,NFSDS>
        TSTB    HCFLG
        BNE     JS10                ;BR IF HCOPY IS OPERATING
        INCB    HCFLG               ;SET HCOPY OPERATING
        BIS     #1,@#LITES          ;TURN ON HCOPY LITE
        MOV     CMDS,CMDS
        MOV     @CSBN,A+SBN         ;SET UP START BLOCK NUMBER
        MOV     @#PSW,-(SP)         ;SAVE PSW TO SIMULATE TRAP
        JSR     PC,HCOPY            ;CALL HCOPY
JS10:   JMP     S10
        .PAGE
        PLOC=60000                  ;PHASE START LOCATION
PHASE:  MOV     @2(R5),R1
        MOV     R1,PNUM             ;STORE PHASE NUMBER
        INC     R1
        MOV     R1,NPHASE           ;NPHASE=PNUM+1
        .CALL   ZIA,<157000,L377>       ;ZERO 510 BYTES OF UPPER CORE
        .CALL   READ,<MYB,PNUM,INDEX,PLOC>      ;READ PHASE PNUM INTO PLOC
        ASL     R1
        ADD     #PLITE-4,R1
        BIS     @R1,@#LITES         ;TURN ON THE LITE FOR THIS PHASE
        .CALL   PLOC,<DUNIT,FILPEX> ;CALL THE PHASE, GIVING IT A DATA SET NAME
        BIC     #14176,@#LITES      ;TURN OFF ANALYSIS LITES
        RTS     R5
;
PPAR:   .CALL   PARAM,<NP,PAR,MAXNP>    ;JSR PC,PPAR
        DEC     NP
        BMI     PPEXT               ;BR IF NP WAS 0
        CMPB    PAR,#'N
        BEQ     PPEXT               ;BR IF NO RESTART
        CMPB    PAR,#'Y
        BEQ     RSTRT               ;BR IF A RESTART
        JMP     PP40                ;PHASE NUMBER AND PARAMETERS
PPEXT:  RTS     PC
RSTRT:  TSTB    SFLAG               ;JSR PC,RSTRT
        BNE     PP05                ;BR IF SEARCHING
        .CALL   TYPE,<M4,ZERO>      ;ASK ABOUT SCAN RESTART
        .CALL   PARAM,<NP,PAR,MAXNP>
        CMPB    PARBUF,#'Y
        BNE     PP05                ;BR IF NO SCAN RESTART
        .CALL   RPARAM,<NP,SOURCE,L512,ONE>     ;READ RESTART INFO
        .CALL   TYPE,<M7,ZERO>      ;ASK FOR FIRST SPREAD NUMBER
        .CALL   PARAM,<NP,PAR,MAXNP>
        MOV     PAR,R0
        CMP     R0,#1
        BLE     PP02                ;BR IF NUMBER LE 1
        CMP     R0,NSCAN
        BGT     PP02                ;BR IF GT NSCAN
        DEC     R0                  ;LEGAL NUMBER, DECREMENT IT
        MOV     R0,SPN              ;STORE IT
        SUB     R0,NSCAN            ;ADJUST NSCAN
        ASL     R0
        ASL     R0                  ;N*4
        ADD     R0,CSPQ             ;ADJUST CSPQ
PP02:   .CALL   GNSTS   ;GET FIRST SPREAD TO SCAN AND ENABLE SPIRAL SEARCH
        .CALL   LED,<SQLED,NSCAN>
PP05:   .CALL   TYPE,<M5,ZERO>  ;ASK ABOUT ANALYSIS RESTART
        .CALL   PARAM,<NP,PAR,MAXNP>
        CMPB    PARBUF,#'Y
        BNE     PP15                ;BR IF NO ANALYSIS RESTART
        CLR     NPHASE              ;NPHASE=0
        MOV     #NSDS,R0
        MOV     @SDS,R1
```

```
        MOV     R0,NFSDS        ;SET ALL SCAN DATA SETS AS FULL
PP10:   MOVB    R0,(R1)+
        SOB     R0,PP10
        .CALL   TYPE,<M8,ZERO>  ;ASK HOW MANY
        .CALL   PARAM,<NP,PAR,MAXNP>
        TST     PAR
        BLE     PP12            ;BR IF N LE 0
        CMP     PAR,#NSDS
        BGE     PP12            ;BR IF N GE NSDS
        MOV     PAR,NFSDS       ;STORE NFSDS
PP12:   .CALL   LED,<AQLED,NFSDS>       ;DISPLAY ANALYSIS QUEUE
PP15:   TSTB    HCFLG
        BNE     PPEX            ;BR IF HCOPY RUNNING
        .CALL   TYPE,<M6,ZERO>  ;ASK ABOUT HARDCOPY RESTART
        .CALL   PARAM,<NP,PAR,MAXNP>
        CMPB    PARBUF,#'Y
        BNE     PPEX            ;BR IF NO HARDCOPY RESTART
        MOV     #NHDS,R0
        MOV     #HDS,R1
        .CALL   TYPE,<M8,ZERO>  ;ASK HOW MANY
        .CALL   PARAM,<NP,PAR,MAXNP>
        TST     PAR
        BLE     PP18            ;BR IF N LE 0
        CMP     PAR,#NHDS
        BGE     PP18            ;BR IF N GE NHDS
        MOV     PAR,R0          ;LEGAL N
PP18:   MOV     R0,NHCOPY       ;SET N HARDCOPY DATA SETS AS FULL
PP20:   MOVB    #-1,(R1)+
        SOB     R0,PP20
        INCB    HCFLG           ;SET HARDCOPY OPERATING
        BIS     #1,@#LITES      ;TURN ON HARDCOPY LITE
        MOV     @#PSW,-(SP)
        JSR     PC,HCLED        ;SIMULATE INTERRUPT TO HCOPY END RTE
PPEX:   RTS     PC
PP40:   MOV     PAR,R0          ;PHASE NUMBER
        BLE     PERR
        CMP     R0,#NPH
        BGT     PERR
        ASL     R0
        ADD     #DNPTAB-2,R0    ;DNPTAB+2*PNUM-2
        MOV     NP,@R0          ;STORE NP FOR THE PHASE
        .CALL   WPARAM,<NP,PAR+2,P&R>
JPPAR:  JMP     PPAR
PERR:   .CALL   TYPE,<PEMSG,ZERO>
        BR      JPPAR
;
TNSCAN: TST     NSCAN           ;JSR PC,TNSCAN
        BNE     CGNS            ;BR IF NSCAN NOT ZERO
        .CALL   TYPE,MSG1       ;TYPE 'OK TO START SEARCH'
        .CALL   SEARCH          ;ALLOW SEARCH START
        RTS     PC
CGNS:   .CALL   GNSTS           ;GET NEXT SPREAD TO SCAN
        RTS     PC
;
MVB:    .BLKW   10.             ;MVB FOR READING PHASE FROM CALMS.OVR
        .BYTE   1,5             ;DK5:
        .RAD50  /DK/
        .BLKW   2
        .RAD50  /CALMS OVR/
        .BYTE   2,2
        .BLKW   10.
L377:   .WORD   377
PSIZE:  .WORD   32256.
TWO:    .WORD   2
INDEX:  .WORD   .-.
FPHASE: .WORD   2               ;FIRST ANALYSIS PHASE (OR DEBUG PHASE)
MPHASE  .WORD   MASKPH
PPHASE: .WORD   16.             ;PREP PHASE
EPHASE  .WORD   17.             ;TEXT EDITOR PHASE
FPASE:  .WORD   18.             ;FORTRN PHASE
DUNIT:  .WORD   .-.             ;DISK UNIT FOR SCAN OR HARDCOPY DATA SET
LNAM:   .ASCII  /OVO/
PLNAM:  .ASCII  /PAR/
```

```
PMVB:   .BLKW   10.             ;MVB FOR WRITING AND READING PARAMETERS
        .BYTE   1,1             ;DK1:
        .RAD50  /DK /
        .BLKW   2
        .RAD50  /CALMS PAR/     ;CALMS.PAR
        .BYTE   2,2             ;[2,2]
        .BLKW   10.
PARSIZ: .WORD   1024.
PLITE:  .WORD   100,40,40,40,40,40,20,10,10,10,4,2,2,10010,10010,4000
        .WORD   4000,4000,4000,10010,0,0,0,0
NPTAB:  .BLKW   NPH             ;NP TABLE
DNPTAB: .BLKW   NPH             ;DEFAULT NP TABLE
        .PAGE
        HCWC=172430             ;HARDCOPY WORD COUNT REGISTER
        HCAD=172432
        HCST=172434
        HCMD=172434
        HCIV1=440
        HCIV2=442
        INTPS=340               ;INTERRUPT PRIORITY LEVEL 7
HCOPY:  MOV     #77777,A        ;CLEAR ACTIVE BLOCK NUMBER
        MOV     #77777,A+IBN    ;AND INACTIVE BLOCK NUMBER
        MOV     #SLAB,A+2       ;READ LABEL INTO SLAB
        MOV     #LABSIZ,A+BUFSIZ        ;READ LABSIZ BYTES
        CLRB    A+DBFLAG        ;PREVENT READ-AHEAD
        CLR     A+CURREC        ;CLEAR CURRENT RECORD NUMBER
        .CALL   GLABEL,<A,SPAR,IA>
;READ THE LABEL INFORMATION INTO LOW CORE AND CALCULATE RECLEN.
;THEN, SET UP THE MVB TO USE TWO 4096 BYTE BUFFERS IN HIGH CORE
;FOR THE DISK TO CORE TO HARD-COPY DMA TRANSFER.
        MOV     #77777,A        ;CLEAR ACTIVE BLOCK NUMBER
        MOV     #160000,A+2     ;ONE BUFFER AT 160000
        MOV     #77777,A+IBN    ;CLEAR INACTIVE BLOCK NUMBER
        MOV     #170000,A+IBA   ;ONE BUFFER AT 170000
        MOV     #10000,A+BUFSIZ ;BUFSIZ=4096 BYTES
        MOV     #10,A+BPB       ;8 BLOCKS PER BUFFER
        INCB    A+DBFLAG        ;SET DOUBLE BUFFERING
;
        CLR     LINE                    ;INITIALIZE LINE COUNTER
        MOV     #INTRY,@#HCIV1          ;INT ENTRY ADDR TO HCPY INT VEC
        MOV     #INTPS,@#HCIV2          ;INT SVC PSW TO HCPY INT VEC
        INC     BPL                     ;IN CASE OF ODD BYTES
        ASR     BPL                     ;WD CNT FOR HCPY LINE IS BPL/2
        MOV     BPL,BPL2
        ASL     BPL2            ;2*WDCNT
        MOV     A+54,RMB                ;RECLEN
        SUB     BPL,RMB
        SUB     BPL,RMB
        MOV     #160000,@#HCAD
        SUB     RMB,@#HCAD
        CLR     @#HCWC                  ;CLEAR HCPY WD CNT REGISTER
ONTST:  CLR     @#HCST                  ;TEST FOR HCPY DEVICE ON
        BIT     #2000,@#HCST            ;BIT-10 IS HC RUNNING
        BNE     ONTST                   ;WAIT FOR PREVIOUS END-FRAME
        BIT     #4000,@#HCST            ;BIT-11 IS HC READY
        BNE     REPL                    ;BR IF HC READY
HCOFF:  MOV     @#HCST,-(SP)            ;DISPLAY HCST
        MOV     #501,-(SP)              ;A101 MSG, HC OFF
IOT:    IOT                             ;ACTION MSG TO OPERATOR
        BR      ONTST                   ;CHECK HCPY DEVICE AGAIN

;  HARDCOPY DEVICE INTERRUPT SERVICE ROUTINE
;
INTRY:  BIT     #10000,@#SWR
        BNE     NXTLN           ;BR IF SW 12 UP
        COM     LXPND
        BEQ     NXTLN           ;BR IF NEW LINE
        SUB     BPL2,@#HCAD     ;RESTORE HCAD
        BR      NOGET           ;REPEAT THE LAST LINE
NXTLN:  DEC     NL                      ;DECREMENT LINE COUNT & TEST
        BEQ     EODS                    ;BRANCH IF END
REPL:   INC     LINE
        ADD     RMB,@#HCAD
        BIT     #77777,@#HCAD
        BNE     NOGET
```

```
        .CALL   GET,<A,LINE,INDEX>      ;GET LOCATION OF LINE
        MOV     #A,@#HCAD               ;  AND LOAD INTO
        ADD     INDEX,@#HCAD            ;  HC BUS ADDR REG
NOGET:  SUB     #DCNT,@#HCWC    ;STORE NEGATIVE WORD COUNT
        MOV     #113,@#HCMD     ;COMMAND LINE OUTPUT WITH PDATA=1, LXPND=0
        RTI                             ;RETURN FROM INTERRUPT
;
EODS:   CLR     @#HCST          ;STOP HCOPY DEVICE
        CLR     @#PSW           ;LOWER PRIORITY
        BIT     #4,@#SWR
        BEQ     HCOK            ;BR IF SW 2 DOWN (NO RERUN CHECK)
        TSTB    PBUSY           ;TEST PARAM BUSY BYTE
        BEQ     SCP             ;BR IF NOT
        MOV     #SCP,PINT       ;STORE INTERRUPT ADDRESS
        RTI
SCP:    .CALL   TYPE,<MSG3,ZERO>
        .CALL   PARAM,<NP,PAR,MAXNP,SPBUF>
        CMPB    SPBUF,#'Y
        BNE     HCOK            ;BR IF OUTPUT WAS OK
        JMP     HCOPY           ;RE-DO THE OUTPUT
HCOK:   CLRB    @CHDS           ;RELEASE THE HCOPY DATASET
        DEC     NHCOPY
HCLED:  .CALL   LED,<#LED,NHCOPY>       ;ENTRY FOR RESTART
        MOV     R0,-(SP)
        MOV     R1,-(SP)
        MOV     #HDS,R0
        MOV     #HDS,R1
        MOV     #HSBN,REG2
H40:    TSTB    (R1)+
        BMI     H50             ;BR IF DATASET IS FULL
        ADD     #2,REG2
        SOB     R0,H40
        CLRB    HCFLG           ;SET HCOPY NO LONGER OPERATING
        BIC     #1,@#LITES      ;TURN OFF HCOPY LITE
        MOV     (SP)+,R1
        MOV     (SP)+,R0
        RTI                             ;RETURN FROM INTERRUPT
H50:    MOV     @REG2,A+SBN     ;SET UP START BLOCK NUMBER
        DEC     R1
        MOV     R1,CHDS
        MOV     (SP)+,R1
        MOV     (SP)+,R0
        JMP     HCOPY           ;START NEW DATASET
        .PAGE
LINTPH: .WORD   INTPH
NP:     .WORD   .-.
PAR:    .BLKW   20
MAXNP:  .WORD   20
LHDU:   .WORD   HDU
ZERO:   .WORD   0
ONE:    .WORD   1
FOUR:   .WORD   4
FIVE:   .WORD   5
TWELVE  .WORD   12.
IA:     .WORD   .-.
A:      .BLKB   MYBSIZ
SLAB:   .BLKB   LABSIZ
SPAR=SLAB+2
NL=SPAR
BPL=SPAR+2
#DCNT=BPL
BPE=SPAR+4
LXPND:  .WORD   .-.
RMB:    .WORD   .-.
BPL2:   .WORD   .-.
LINE:   .WORD   .-.
NFSDS:  .WORD   .-.             ;# OF FULL SCAN DATASETS
CMDS:   .WORD   .-.             ;LOC OF CURRENT MASK DATASET FLAG
CHDS:   .WORD   .-.             ;LOC OF CURRENT HARDCOPY DATASET FLAG
HSBN:   .BLKW   NHDS            ;HARDCOPY DATASET START BLOCK NUMBERS
CSBN:   .WORD   .-.
REG2    .WORD   .-.
XVAL:   .WORD   2000.
YVAL:   .WORD   2000.
```

```
NHCOPY: .WORD   .-.             ;# IN HCOPY QUEUE
SFLAG:  .BYTE   0               ;FLAG FOR SEARCH OPERATING
SDS:    .BLKB   NSDS            ;SCAN DATA SET FLAGS
HDS:    .BLKB   NHDS            ;HARDCOPY DATA SET FLAGS
HCFLG:  .BYTE   0               ;FLAG FOR HARDCOPY OPERATING
RFLAG:  .BYTE   0               ;FLAG FOR RESTART REQUEST
PFLAG:  .BYTE   0               ;FLAG TO CALL THE PATIENT REPORTER
EFLAG:  .BYTE   0               ;FLAG TO CALL THE TEXT EDITOR
FRFLAG: .BYTE   0               ;FLAG TO CALL FORTRN
BLZE:   .ASCIZ  / /
MSG1:   .ASCIZ  / OK TO START SEARCH/<LF><LF>
MSG2:   .ASCIZ  / IS THIS A RESTART? /
PEMSG:  .ASCIZ  / ILLEGAL PHASE NUMBER! /
MSG3:   .ASCIZ  / RERUN HCOPY? /
M4:     .ASCIZ  / RESTART SCAN? /
M5:     .ASCIZ  / RESTART ANALYSIS? /
M6:     .ASCIZ  / RESTART HARDCOPY? /
M7:     .ASCIZ  / WHICH SPREAD? /
M8:     .ASCIZ  / HOW MANY SPREADS? /
SPBUF:  .BLKB   83.             ;HCOPY PARBUF
FILPEX: .ASCII  /H*     /
LNAME:  .ASCII  /XXX/
        .EVEN
        .BLKB   SOURCE+13000-.  ;MAKE PROGRAM LENGTH CONSTANT
        .END    CALMS


        .TITLE  SEARCH - SEARCH PARTITION OF CALMS
        .MCALL  .CALL, .PAUSE
        LF=12
        CR=15
        FTIME=15.               ;MAX TIME BETWEEN FOCUS DURING SEARCH
        PSW=177776
        SWR=177570
        .MACRO  GETKB   MSG,?LOC
        TSTB    PBUSY
        BEQ     LOC
        MOV     #LOC,PINT+2
        RTI
LOC:    CLR     @#PSW
        .CALL   TYPE,<MSG,ZERO>
        .ENDM
;
        .MACRO  ENI     CODE    ;ENABLE INTERRUPT
        BIS     #CODE,@#IEAPD
        .ENDM
;
        .MACRO  DSI     CODE    ;DISABLE INTERRUPT
        BIC     #CODE,@#IEAPD
        .ENDM
;
        .MACRO  LON CODE        ;TURN LIGHT ON
        BIS     #CODE,@#LITES
        .ENDM
;
        .MACRO  LOFF CODE       ;TURN LIGHT OFF
        BIC     #CODE,@#LITES
        .ENDM
;
        .MACRO  HINT KEY        ;HANDLE INTERRUPT FOR KEYS 5-8 (AC,RJ,NX,LA)
        DSI     100
        LOFF    100000
        MOV     R0,-(SP)
        .CALL   LED,<LKLED,KEY>
        .ENDM
;
;       CURRENT ORIGIN IS 40000
;
GNSTS:  JMP     GNS             ;ENTRY POINT FOR GNSTS
;
SEARCH: MOV     #SRSTA,R0       ;INITIAL CALL FROM SUPERVISOR
        MOV     #SRST,(R0)+     ;SET UP SEARCH START INTERRUPT VECTO
        MOV     #200,(R0)+      ;PRIORITY 4
        MOV     #15.,R1
```

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IS20:   MOV     #UINT,(R0)+     ;UNEXPECTED INTERRUPT RTE TO OTHERS
        MOV     #200,(R0)+      ;PRIORITY 4
        SOB     R1,IS20
        MOV     #FOC,@#FOCA
        MOV     #KYRQ,@#KYRQA
        MOV     #200,@#KYRQA+2
        .CALL   MFST,(MAGN,FPOS)
        ENI     1410            ;ENABLE SRCH START, FOCUS AND KBD REQUEST
        DSI     367             ;DISABLE OTHERS
        RTS     R5              ;RETURN TO SUPERVISOR
UINT:   .PAUSE  IEAPD           ;UNEXPECTED INTERRUPT
        RTI
SRST:   DSI     10
        .CALL   LED,(LKLED,SSKEY)
        GETKB   M1              ;GET KEYBOARD AND TYPE M1
        .CALL   PARAM,(NP,PAR,MAXNP,SPBUF)
        CMP     NP,#2
        BNE     SR20            ;BR IF NOT 2 WORDS
        CMP     PAR,#"A
        BNE     SR20            ;BR IF NOT ABORT
        .CALL   TYPE,M7         ;SEARCH ABORTED, TYPE M7
        ENI     10
        RTI
SR20:   INCB    SFLAG           ;SET SEARCH OPERATING
        LOFF    162599          ;TURN OFF EDIT LIGHTS
        LON     1000            ;TURN SEARCH LIGHT ON
        TST     NP
        BEQ     SR30            ;BR IF SAME PATIENT AND SLIDE
        .CALL   MVCR,(SPBUF,PANUM,LPANUM)       ;MOVE PATIENT NUMBER
        .CALL   TYPE,(M2,ZERO)
        MOVB    #' ,PAR         ;INITIALIZE SEX TO BLANK
        .CALL   PARAM,(NP,PAR,MAXNP,SPBUF)
        MOVB    PAR,PASEX       ;STORE PATIENT SEX
        .CALL   TYPE,(M3,ZERO)
        .CALL   PARAM,(NP,PAR,MAXNP,SPBUF)
        .CALL   MVCR,(SPBUF,SLNUM,LSLNUM)       ;MOVE SLIDE NUMBER
        .CALL   TYPE,(M8,ZERO)
        .CALL   PARAM,(NP,PAR,MAXNP,SPBUF)
        MOV     PAR,SOURCE      ;STORE SOURCE CODE
SR30:   MOV     #SPQ,CSPQ       ;INITIALIZE SEARCH QUEUE POINTER
        CLR     NSP             ;NSP=0
        MOV     R0,-(SP)        ;SAVE R0 BEFORE CALLING ZIA
        .CALL   ZIA,(SPR,LSPR)  ;ZERO THE SPREAD RATINGS
        MOV     (SP)+,R0
        .CALL   LED,(SNLED,NSP)
        .CALL   MFST,(MAGN,FPOS)
        MOV     XLGTH,XCTR      ;INITIALIZE SEARCH PATTERN
        MOV     IXDEL,XDEL
        MOV     #SDR,@#SDFPA    ;SEARCH DATA READY INTERRUPT
        MOV     #SRHA,@#SRHAA
        MOV     #SRRS,@#SRRSA
        MOV     #EDST,@#EDSTA
        ENI     74              ;ENABLE INTERRUPTS
        RTI
;
FOC:    .CALL   LED,(LKLED,FOKEY)       ;FOCUS INTERRUPT FROM FOCUS KEY
FOCSUB: DSI     400                     ;FOCUS SUBROUTINE
        LON     40000           ;IT MAY BE ENTERED BY ANOTHER INTERRUPT
        MOV     #FTIME,FCNT     ;RESET FOCUS COUNT
        MOV     @#IEAPD,OIEAPD  ;SAVE OLD IEAPD AND SDFPA
        MOV     @#SDFPA,OSDFPA
        .CALL   MFST,(MAGN,FPOS);FIND FSTEP & FLAST FOR THIS MAGNIFICATION
        MOV     #F410,@#SDFPA   ;SET UP INTERRUPT VECTOR
        ENI     4
        RTI
F410:   .CALL   CFOC,OLDF       ;CALCULATE FOCUS
        .CALL   IFREL,FSTEP
F420:   MOV     #F430,@#SDFPA
        RTI
F430:   .CALL   CFOC,F
        CMP     F,OLDF          ;SEE IF WE ARE GOING IN THE RIGHT DIR
        BGT     F450            ;BR IF SO
        MOV     FSTEP,N         ;CHANGE DIRECTION
        ASL     N
        NEG     N               ;MOVE TWICE AS FAR IN REVERSE
```

```
        .CALL   IFREL,N
        MOV     #F440,@#SDFPA
        RTI
F440:   .CALL   CFOC,F
        CMP     F,OLDF          ;SEE IF OTHER DIRECTION IS BETTER
        BGT     F448            ;BR IF SO
        CMP     FSTEP,FLAST     ;SEE IF STEP SIZE IS SMALL ENOUGH
        BLE     F480            ;BR IF SO
        MOV     FSTEP,N         ;TRY A SMALLER STEP
        ASR     FSTEP
        ADD     FSTEP,N         ;N=FSTEP+FSTEP/2
        .CALL   IFREL,N
        BR      F420
F448:   NEG     FSTEP
F450:   MOV     F,OLDF
        .CALL   IFREL,FSTEP     ;TAKE ANOTHER STEP
        MOV     #F460,@#SDFPA
        RTI
F460:   .CALL   CFOC,F
        CMP     F,OLDF
        BGT     F450            ;BR IF FOCUS STILL INCREASING
        MOV     FSTEP,N
        BPL     F470            ;GET ABSOLUTE VALUE FOR TEST
        NEG     N
F470:   NEG     FSTEP
        CMP     N,FLAST         ;TEST FOR LAST STEP
        BLE     F480            ;BR IF SO
        ASR     FSTEP           ;DECREASE STEP SIZE
        BR      F450
F480:   .CALL   IFREL,FSTEP     ;TAKE LAST STEP BACK
        MOV     #F490,@#SDFPA
        RTI
F490:   DSI     4
        .CALL   RMCI
        MOV     OSDFPA,@#SDFPA  ;RESTORE SDFPA
        BIT     #4,OIEAPD       ;SEE IF INTERRUPT WAS ENABLED
        BEQ     F500            ;BR IF NOT
        BIT     #1000,@#LITES
        BEQ     F498            ;RE-ENABLE IT IF NOT IN SEARCH
        TST     @#SPRD
        BPL     F498            ;OR SPREAD NOT PRESENT
        BIT     #4000,@#SWR
        BEQ     F498            ;OR SW 11 DOWN
        LON     20000           ;TURN ON SEARCH HALTED LIGHT
        BR      F500            ;DON'T RE-ENABLE THE INTERRUPT
F498:   ENI     4               ;RE-ENABLE INTERRUPT
F500:   ENI     400
        LOFF    40000           ;TURN OFF FOCUSING LITE
        RTI
;
KYRQ:   DSI     1000            ;DISABLE ANY FURTHER KBD REQ
        .CALL   LED,<LKLED,KRKEY>
        GETKB   M4
        .CALL   PARAM,<NP,PAR,MAXNP,SPBUF>
        TST     NP
        BEQ     BKYEX           ;BR IF NO INPUT
        CMPB    PAR,#'A
        BNE     KY10            ;BR IF NOT ABORT REQUEST
        .CALL   APHASE,<ZERO>
        BR      BKYEX
KY10:   CMPB    PAR,#'C
        BNE     KY20            ;BR IF NOT CALIBRATE MICROSCOPE
        .CALL   IXREL,BIG
        .CALL   IYREL,BIG       ;MOVE TO LIMITS
        .CALL   IFREL,BIG
        .CALL   XWAIT
        .CALL   YWAIT
        .CALL   FWAIT           ;WAIT FOR END OF MOVES
        .CALL   IFCPR           ;INITIALIZE F,X, AND Y
        .CALL   IXCPR
        .CALL   IYCPR
        .CALL   IXYABS,<XVAL,YVAL>;MOVE STAGE TO 1000,1000 OR LAST POSITION
```

```
        .CALL   IFREL,FVAL      ;MOVE FOCUS TO 3000
        .CALL   XWAIT
        .CALL   YWAIT
        .CALL   FWAIT
        .CALL   RMCI
BKYEX:  BR      KYEX
KY20:   CMPB    PAR,#'R
        BNE     KY30            ;BR IF NOT RESTART REQUEST
        INCB    RFLAG           ;SET RESTART FLAG IN CALMS
KY30:   CMPB    PAR,#'E
        BNE     KY35            ;BR IF NOT EDIT REQUEST
        INCB    EFLAG           ;SET EDIT FLAG
        BR      KYEX
KY35:   CMPB    PAR,#'F
        BNE     KY40            ;BR IF NOT FORTRN REQUEST
        INCB    FRFLAG          ;SET FORTRN FLAG
        BR      KYEX
KY40:   CMPB    PAR,#'Z
        BNE     KY50            ;BR IF NOT ZERO SCAN QUEUE REQUEST
        CLR     NSCAN
        .CALL   LED,<SQLED,NSCAN>
        MOV     #SRST,@#SRSTA   ;ALLOW SEARCH START
        BR      KYEX
KY50:   CMPB    PAR,#'Q
        BNE     KY60            ;BR IF NOT QUEUE ADJUST
        MOV     @#XCPR,XOFF
        SUB     XVAL,XOFF       ;STORE X OFFSET
        MOV     @#YCPR,YOFF
        SUB     YVAL,YOFF       ;STORE Y OFFSET
        BR      KYEX
KY60:   CMPB    PAR,#'S
        BNE     KY70            ;BR IF NOT SCAN REQUEST
KY65:   INC     NSCAN
        .CALL   LED,<SQLED,NSCAN>
        MOV     #SPSRCH,@#SRSTA ;SET UP SPIRAL SEARCH
        CMP     NP,#4           ;SEE IF X AND Y WERE GIVEN
        BNE     KYEX            ;BR IF NOT
        .CALL   IXYABS,<PAR+4,PAR+6>
        ENI     1000
        JMP     FOCSUB
KY70:   CMPB    PAR,#'D
        BNE     KY80            ;BR IF NOT DEBUG REQUEST
        MOV     PAR+4,FPHASE    ;STORE PHASE NUMBER
        BR      KY65            ;GO INCREMENT NSCAN
KY80:   CMPB    PAR,#'B
        BNE     KY90            ;BR IF NOT BANDED REQUEST
        MOV     #-8.,SOURCE     ;SET SOURCE OF -8
        BR      KYEX
KY90:   CMPB    PAR,#'P
        BNE     KY100           ;BR IF NOT PATIENT REPORT REQUEST
        INCB    PFLAG           ;SET PREP FLAG
        .CALL   WPARAM,<ONE,PAR,FPHASE> ;WRITE PREP PARAM
        BR      KYEX
KY100:

KYEX:   ENI     1000
        RTI
;
SDR:    TST     @#SPRD          ;SPREAD DATA READY (SEARCH)
        BMI     SPRES           ;BR IF SPREAD PRESENT
        MOV     #1,FFLAG        ;RESET FOCUS FLAG
        DEC     FCNT            ;DECREMENT FOCUS COUNT
        BPL     CNP             ;BR IF NO NEED TO FOCUS
        BIT     #60000,@#SPRD
        BEQ     CNP             ;BR IF NOTHING TO FOCUS ON
        JMP     FOCSUB          ;GO FOCUS
SPRES:  NEG     FFLAG
        BPL     NOFOC           ;BR IF NO FOCUS THIS TIME
        JMP     FOCSUB          ;GO TO FOCUS SUBROUTINE
NOFOC:  MOV     R0,-(SP)
        MOV     CSPQ,R0         ;R0=CURRENT SPREAD QUEUE POINTER
        MOV     @#XCPR,(R0)+    ;STORE X
        BPL     XOK             ;BR IF X IS POSITIVE
XYNG:   GETKB   M6              ;REQUEST CALIBRATION
        MOV     (SP)+,R0
```

```
        DSI     4               ;DISABLE INTERRUPT
        RTI
XOK:    MOV     @#YCPR,(R0)+    ;STORE Y
        BMI     XYNG            ;BR IF Y IS NEGATIVE
        CMP     MAGN,#63.       ;SEE IF SEARCH IS AT HI-MAG
        BLT     LOMAG
        NEG     -4(R0)          ;IF AT HI-MAG, FLAG AS ACCEPTED IN ED-LO
LOMAG:  MOV     R0,CSPQ
        MOV     (SP)+,R0
        INC     NSP             ;INCREMENT # SPREADS FOUND
        .CALL   LED,<SNLED,NSP>
        CMP     NSP,MAXNSP
        BGE     EDLO            ;BR IF ENOUGH SPREADS FOUND
CNP:    TST     XCTR
        BGT     G50             ;BR IF ANOTHER X MOVE IS OK
        BLT     G40             ;BR IF LAST MOVE WAS A Y
        NEG     XDEL            ;END OF ROW, REVERSE DIRECTION
        .CALL   IYREL,<YDEL>    ;AFTER MOVING DOWN
        BR      G60
G40:    MOV     XLGTH,XCTR      ;RELOAD XCTR
G50:    .CALL   IXREL,<XDEL>    ;MOVE IN X DIRECTION
G60:    DEC     XCTR
        BIS     #4,@#IEAPD      ;ENABLE INTERRUPT
        RTI
;
SRHA:   DSI     4               ;SEARCH OR FOCUS HALT
        BIC     #4,@IEAPD       ;PREVENT END OF FOCUS FROM RESUMING SRCH
        .CALL   LED,<LKLED,SHAKEY>
        LON     20000           ;TURN ON SEARCH HALTED LIGHT
        .CALL   RMCI
        RTI
;
SRRS:   ENI     4               ;SEARCH OR FOCUS RESUME
        .CALL   LED,<LKLED,RSKEY>
        LOFF    20000           ;TURN OFF SEARCH HALTED LIGHT
        RTI
;
EDST:   DSI     104             ;EDIT START
        LOFF    120000
        .CALL   LED,<LKLED,ESKEY>
        .CALL   MFST,<MAGN,FPOS>
        ENI     400             ;ENABLE FOCUS INTERRUPT
        MOV     #1,FFLAG        ;INITIALIZE FOCUS FLAG
        BIT     #1000,@#LITES
        BNE     EDLO            ;BR TO EDIT-LO IF IN SEARCH
        BIT     #400,@#LITES
        BNE     ES40            ;BR IF 9N EDIT-LO
        CMP     MAGN,#63.
        BLT     ELSTT           ;BR IF LO-MAG (IN EDIT-HI)
        JMP     EHRST           ;HI-MAG (IN EDIT-HI)
ES40:   CMP     MAGN,#63.       ;IN EDIT-LO, TEST MAG
        BLT     ELRST           ;BR IF LO-MAG
        JMP     EHSTT           ;HI-MAG, START EDIT-HI
;
EDLO:   CLR     @CSPQ           ;MARK END OF QUEUE
        DSI     20
        CLR     NSPAL
        CMP     MAGN,#63.
        BLT     ELSTT           ;BR IF LO MAG
        JMP     EHSTT           ;START ED-HI IF HI MAG
ELSTT:  .CALL   LED,<SQLED,NSPAL>
        LOFF    1200
        LON     400             ;TURN ON EDIT LO LIGHT
        MOV     #ELAC,@#ACSPA   ;ACCEPT SPRD
        MOV     #ELRJ,@#RJSPA   ;REJECT SPRD
        MOV     #ELNX,@#NXSPA   ;NEXT SPRD
        MOV     #ELLA,@#LASPA   ;LAST SPRD
ELRST:  CLR     SPN             ;SPREAD NUMBER
        MOV     #SPQ,CSPQ
        MOV     R0,-(SP)        ;SAVE R0 ON THE STACK
EDNXT:  MOV     CSPQ,R0
        LOFF    40000           ;TURN OFF FOCUS LITE IN CASE FOCUS
        ENI     400             ;WAS INTERRUPTED BY ARNL
        INC     SPN
        .CALL   LED,<SNLED,SPN>
```

```
        LOFF    2000
        MOV     (R0)+,X
        BEQ     JEDHI           ;BR IF END OF QUEUE
        BPL     EL30            ;BR IF NOT ALREADY ACCEPTED
        LON     2000            ;INDICATE ALREADY ACCEPTED
EL30:   MOV     (R0)+,Y
        MOV     R0,CSPQ         ;SAVE UPDATED Q POINTER
        MOV     (SP)+,R0        ;RESTORE R0
        .CALL   IXYABS,<X,Y>    ;INITIATE MOTOR MOVE TO X,Y
        MOV     #ESDR,@#SDFPA
        MOV     #1,FFLAG
        ENI     4               ;ENABLE SPRD DATA READY INTERRUPT
        RTI
;
JEDHI:  JMP     EDHI
;
ESDR:   ENI     100             ;ALLOW RJ DURING FOCUS
        NEG     FFLAG           ;EDIT SPREAD DATA READY
        BPL     ES20            ;BR IF NO FOCUS THIS TIME
        JMP     FOCSUB
ES20:   DSI     4               ;NOW DISABLE THE SDR INTERRUPT
        .CALL   RMCI            ;RELASE MCI FROM COMPUTER CONTROL
        LON     100000          ;TURN ON OPERATOR ACTION LIGHT
        RTI
;
ELAC:   HINT    ACKEY           ;ACCEPT SPRD INTERRUPT
        MOV     CSPQ,R0
        TST     -4(R0)
        BPL     ELA20           ;BR IF NOT PREVIOUSLY ACCEPTED
        DEC     NSPAL           ;DON'T COUNT IT TWICE
ELA20:  MOV     @#YCPR,-(R0)    ;STORE UPDATED Y AND X
        MOV     @#XCPR,-(R0)
        NEG     @R0             ;MAKE X NEGATIVE TO FLAG THIS SPREAD
        INC     NSPAL
        .CALL   LED,<SQLED,NSPAL>
        CMP     NSPAL,NLMAX
        BGE     EDHI            ;BR IF ENOUGH FOUND
        BR      EDNXT           ;GO TO NEXT SPREAD
;
ELRJ:   HINT    RJKEY           ;REJECT SPREAD INTERRUPT
        MOV     CSPQ,R0
        TST     -4(R0)
        BPL     JEDNXT          ;BR IF NOT PREVIOUSLY ACCEPTED
        NEG     -4(R0)          ;MARK IT REJECTED X+
        DEC     NSPAL
        .CALL   LED,<SQLED,NSPAL>
        BR      JEDNXT
ELNX:   HINT    NXKEY           ;NEXT SPREAD
        BR      JEDNXT
;
ELLA:   HINT    LAKEY           ;LAST SPREAD
        SUB     #4,CSPQ         ;MOVE BACK TO CURRENT SPREAD
        DEC     SPN
        BEQ     JEDNXT          ;BR IF FIRST SPREAD IN QUEUE
        SUB     #4,CSPQ         ;BACK UP ANOTHER SPREAD
        DEC     SPN
JEDNXT  JMP     EDNXT
;
EDHI:   MOV     (SP)+,R0        ;RESTORE R0
        GETKB   M5              ;REQUEST HI MAGNIFICATION
EHSTT:  LOFF    1400
        LON     200             ;TURN ON EDIT HI LIGHT
        MOV     #EHAC,@#ACSPA   ;SET UP EDIT HI INTERRUPTS
        MOV     #EHRJ,@#RJSPA
        MOV     #EHNX,@#NXSPA
        MOV     #EHLA,@#LASPA
        MOV     #EDEN,@#EDENA
        ENI     200
        CLR     NSCAN
        .CALL   LED,<SQLED,NSCAN>
EHRST:  CLR     SPN
        MOV     #SPQ,CSPQ
        MOV     R0,-(SP)        ;SAVE R0
EHNXT:  MOV     CSPQ,R0
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```
        LOFF    40000           ;TURN OFF FOCUS LITE IN CASE FOCUS
        ENI     400             ;WAS INTERRUPTED BY ARNL
EH10:   INC     SPN
        MOV     (R0)+,X
        BEQ     JEDEND          ;BR IF END OF QUEUE
        BMI     EH20            ;BR IF -X (ACCEPTED IN EDIT LO)
        TST     (R0)+
        BR      EH10            ;TRY THE NEXT SPREAD
EH20:   LOFF    2000
        MOV     (R0)+,Y
        BPL     EH30            ;BR IF NOT ALREADY ACCEPTED
        LON     2000            ;TURN ON LITE
        BR      EH40            ;NO ADJUSTMENT IF ALREADY ACCEPTED
EH30:   .CALL   MFST,<MAGN,FPOS>        ;SETUP XADJ AND YADJ
        SUB     XADJ,X          ;X IS NEGATIVE, ADJUST FOR CENTRALITY
        ADD     YADJ,Y          ;ADJUST POSITIVE Y FOR CENTRALITY
EH40:   MOV     R0,CSPQ
        MOV     (SP)+,R0        ;RESTORE R0
        .CALL   LED,<SNLED,SPN>
        .CALL   IXYABS,<X,Y>    ;INITIATE MOVE TO X,Y
        MOV     #ESDR,@#SDFPA
        MOV     #1,FFLAG
        ENI     4               ;ENABLE SPRD DATA READY INTERRUPT
        RTI
JEDEND: JMP     EDEND
;
EHAC:   HINT    ACKEY           ;ED HI ACCEPT
        MOV     CSPQ,R0
        TST     -2(R0)
        BPL     EHA20           ;BR IF NOT ALREADY ACCEPTED AT HI MAG
        DEC     NSCAN           ;DON'T COUNT IT TWICE
EHA20:  MOV     @#YCPR,-(R0)
        NEG     @R0             ;STORE -X AND -Y
        MOV     @#XCPR,-(R0)
        NEG     @R0
        INC     NSCAN
        .CALL   LED,<SQLED,NSCAN>
        SUB     #SPQ,R0         ;FIND LOC IN SPR
        ASH     #-2,R0
        INCB    SPR(R0)         ;INCREMENT SPREAD RATING
        MOV     (SP)+,R0
        LON     100000
        ENI     100
        RTI                     ;RETURN FOR ANOTHER AC OR NX
;
EHRJ:   HINT    RJKEY           ;ED HI REJECT
        MOV     CSPQ,R0
        TST     -(R0)
        BPL     EHNXT
        NEG     @R0             ;MAKE IT POSITIVE IF PREVIOUSLY ACCEPTED
        DEC     NSCAN
        TST     -(R0)           ;GET LOC IN SPR FOR THE SPREAD
        SUB     #SPQ,R0
        ASH     #-2,R0
        CLRB    SPR(R0)         ;ZERO THE SPREAD RATING
        .CALL   LED,<SQLED,NSCAN>
        BR      JEHNXT
;
EHNX:   HINT    NXKEY
        CMP     NSCAN,MAXSC
        BGE     EDEND           ;BR IF ENOUGH FOUND
        BR      JEHNXT
;
EHLA:   HINT    LAKEY           ;ED HI LAST
        SUB     #4,CSPQ
        DEC     SPN
        BEQ     JEHNXT          ;BR IF FIRST SPRD IN Q
EHL20:  SUB     #4,CSPQ         ;MOVE BACK ANOTHER SPREAD
        DEC     SPN
        BEQ     JEHNXT
        TST     @CSPQ
        BPL     EHL20           ;BR IF NOT -X
JEHNXT: JMP     EHNXT           ;LAST -X
;
EDEN:   .CALL   LED,<LKLED,EEKEY>
```

```
        MOV     R0,-(SP)
EDEND:  LOFF    102200          ;TURN OFF ED HI AND ACC LIGHT
        DSI     104             ;DISABLE ARNL AND SDR
        TST     NSCAN
        BEQ     EE30            ;BR IF NONE TO SCAN
        DSI     40              ;DISABLE EDIT START
        JSR     R5,SORTQ        ;SORT THE QUEUE ACCORDING TO RATING
        MOV     #SPQ,CSPQ
        CLR     SPN
        .CALL   @PARAM,<L512,SOURCE,ONE>        ;SAVE INFO FOR RESTART
        CLR     XOFF
        CLR     YOFF
        .CALL   GNSTS           ;GET FIRST SPREAD TO SCAN
        BR      EE40
EE39:   MOV     #SRST,@#SRSTA   ;ALLOW SEARCH START
EE40:   MOV     (SP)+,R0        ;RESTORE R0
        CLRB    SFLAG
        RTI
;
;
GNS:    MOV     R0,-(SP)        ;GET NEXT SPREAD TO SCAN SBRTE
        MOV     CSPQ,R0
        MOV     #SPSRCH,@#SRSTA
        ENI     10              ;ENABLE SPIRAL SEARCH
EE10:   INC     SPN             ;LOOK FOR FIRST -Y
        MOV     (R0)+,XVAL
        BEQ     GNEX            ;BR IF END OF QUEUE
        MOV     (R0)+,YVAL
        BPL     EE10            ;BR IF NOT ACCEPTED
        NEG     XVAL            ;MAKE XVAL AND YVAL POSITIVE
        NEG     YVAL
        ADD     XOFF,XVAL       ;ADD OFFSET
        ADD     YOFF,YVAL
        MOV     R0,CSPQ
        .CALL   IXYABS,<XVAL,YVAL>      ;INITIATE MOTOR MOVE
        MOV     @#PSW,-(SP)
        JSR     PC,FOCSUB       ;START FOCUSING
GNEX:   .CALL   LED,<SNLED,SPN>
        MOV     (SP)+,R0
        RTS     R5
;
SPSRCH: .CALL   LED,<LKLED,SSKEY>       ;SPIRAL SEARCH
        CLR     XCTR            ;INITIALIZE SPIRAL SEARCH
        CLR     YCTR
        CLR     SPLEN
        MOV     #SPSDR,@#SDFPA
        MOV     #SRHA,@#SRHAA
        MOV     #SRRS,@#SRRSA
        ENI     24              ;ENABLE SEARCH HALT & RESUME & SDR
        RTI
SPSDR:  BIT     #60000,@#SPRD   ;SEE IF ANYTHING THERE
        BEQ     SGNP            ;BR IF NOT
        NEG     FFLAG
        BPL     SGNP            ;BR IF NO NEED TO FOCUS
        JMP     FOCSUB
SGNP:   TST     XCTR
        BGT     SXOK            ;BR IF ANOTHER X MOVE IS OK
        TST     YCTR
        BGT     SYOK            ;BR IF ANOTHER Y MOVE IS OK
        INC     SPLEN           ;INCREMENT SPIRAL LENGTH
        MOV     SPLEN,XCTR      ;RELOAD X AND Y COUNTERS
        MOV     SPLEN,YCTR
        NEG     SPSTEP          ;CHANGE DIRECTION
SXOK:   .CALL   IXREL,SPSTEP
        DEC     XCTR
        RTI
SYOK:   .CALL   IYREL,SPSTEP
        DEC     YCTR
        RTI
;
SPLEN:  .WORD   .-.             ;SPIRAL LENGTH
SPSTEP: .WORD   5               ;OR -5
YCTR:   .WORD   .-.
BIG:    .WORD   9900.
XOFF:   .WORD   .-.
YOFF:   .WORD   .-.
```

```
FFLAG:  .WORD   1               ;FLAG OSCILLATES FROM 1 TO -1
OIEAPD: .WORD   0
OSDFPA: .WORD   0
F:      .WORD   0
OLDF:   .WORD   0
N:      .WORD   0
;
SSKEY:  .WORD   1
SHAKEY: .WORD   2
RSKEY:  .WORD   3
ESKEY:  .WORD   4
ACKEY:  .WORD   5
RJKEY:  .WORD   6
NXKEY:  .WORD   7
LAKEY:  .WORD   8.
EEKEY:  .WORD   9.
FOKEY:  .WORD   10.
KRKEY:  .WORD   11.
MAXSC:  .WORD   300.            ;MAXIMUM TO SCAN
NLMAX:  .WORD   300.            ;MAXIMUM TO ACCEPT IN EDIT-LO
X:      .WORD   -.
Y:      .WORD   -.
FPOS:   .WORD   -.
MAGN:   .WORD   -.
FCNT:   .WORD   15.+-.          ;TIME TO FOCUS COUNTER
IXDEL:  .WORD   -13.            ;INITIAL XDEL
XDEL:   .WORD   -13.
YDEL:   .WORD   -13.
XCTR:   .WORD   75.+-.
XLGTH:  .WORD   75.
FVAL:   .WORD   -3800.          ;INITIAL FOCUS AFTER CALIBRATION
NSP:    .WORD   0               ;NUMBER OF SPREADS IN THE QUEUE
NSPAL:  .WORD   0
MAXNSP: .WORD   299.            ;MAXIMUM SEARCH QUEUE
LSPR:   .WORD   150.            ;LENGTH OF SPR IN WORDS
L512:   .WORD   512.
ZERO:   .WORD   0
NP:     .WORD   .-.
PAR:    .BLKW   20.
MAXNP:  .WORD   20.
SPBUF:  .BLKB   83.
        .NLIST  BEX
M1:     .ASCIZ  / ENTER PATIENT ID /
M2:     .ASCIZ  / ENTER PATIENT SEX /
M3:     .ASCIZ  / ENTER SLIDE ID /
M4:     .ASCIZ  / ENTER REQUEST /
M5:     .ASCIZ  / CHANGE TO HIGH MAGNIFICATION /<CR><LF><LF>
M6:     .ASCIZ  / PLEASE CALIBRATE THE MICROSCOPE /<CR><LF><LF>
M7:     .ASCIZ  / ILLEGAL ID, SEARCH NOT STARTED/<LF><LF>
M8:     .ASCIZ  / ENTER SOURCE CODE  (NEGATIVE FOR BANDED) /
        .BLKB   GNSTS+7000-.    ;MAKE LENGTH CONSTANT
        .END

        .TITLE  DLINE - DISPLAY A LINE ON THE INTERACTIVE DISPLAY
;       CALMS VERSION
        DRWC=172410             ;WORD COUNT REGISTER
        DRBA=DRWC+2             ;BUS ADDRESS REGISTER
        DRST=DRWC+4             ;STATUS AND COMMAND REGISTER
        YREG=164106             ;LINE REGISTER
        XREG=164104             ;SAMPLE REGISTER
        GSST=164100             ;GRAY SCALE STATUS/COMMAND REGISTER
        GSPC=164110             ;GRAY SCALE PIXEL COUNT REGISTER
        GSXCP=164112            ;GRAY SCALE X CURSOR POSITION
        GSYCP=164114            ;GRAY SCALE Y CURSOR POSITION
        WRCMD=4                 ;WRITE COMMAND
        ERCMD=6                 ;ERASE COMMAND
        EWCMD=2                 ;ERASE/WRITE COMMAND
        RBIT=10                 ;REPLICATE BIT
        SWR=177570
        LF=12
        .MCALL  BIN20,.CALL,.PAUSE
;
;       CALL DWAIT
;
DWAIT:  TST     @#GSST          ;TEST READY BIT
```

```
        BPL     DWAIT           ;BR IF NOT READY
        RTS     R5
;
;       CALL DCLEAR
;
DCLEAR: JSR     R5,DWAIT
        INC     @#GSST          ;STORE CLEAR COMMAND
        RTS     R5
;
;       CALL DLINE(LOC,Y,X,NS,REPL,ERASE) -1=ERASE ONLY
;
DLINE:  JSR     R4,SAVER
        JSR     R5,DWAIT
        MOV     @4(R5),@#YREG   ;STARTING LINE ON DISPLAY
        MOV     #WRCMD,R1
        BIS     #400,@#DRST     ;ASSUME WRITE, SET CYCLE BIT
        TST     @14(R5)
        BEQ     NOER            ;BR IF NO ERASE
        MOV     #EWCMD,R1       ;ASSUME ERASE/WRITE
        TST     @14(R5)
        BPL     NOER            ;BR IF ERASE/WRITE
        MOV     #ERCMD,R1       ;ERASE ONLY
        BIC     #400,@#DRST     ;CLEAR CYCLE BIT
NOER:   MOV     @10(R5),R3      ;NS
        MOV     @12(R5),R2      ;REPL
        BEQ     NOREP           ;BR IF NO REPLICATION
        BIS     #RBIT,R1        ;INSERT REPLICATE BIT
        ASL     R3              ;2*NS
NOREP:  NEG     R3
        MOV     R3,@#GSPC       ;STORE PIXEL COUNT -N OR -2*N
REP:    MOV     2(R5),@#DRBA    ;LOC TO BUS ADDRESS REGISTER
        MOV     @6(R5),@#XREG   ;STARTING SAMPLE ON DISPLAY
        MOV     @10(R5),R3      ;SAMPLE COUNT
        INC     R3
        ASR     R3
        NEG     R3
        MOV     R3,@#DRWC       ;STORE NEGATIVE WORD COUNT
        MOV     R1,@#GSST       ;STORE WRITE OR ERASE/WRITE COMMAND
        INC     @#DRST          ;ISSUE GO
        TST     R2
        BLE     EXIT            ;BR IF DONE
        BIT     #10,@#SWR       ;REPLICATE UNLESS SW 3 IS UP
        BNE     EXIT            ;EXIT IF SW 3 UP
        CLR     R2
        JSR     R5,DWAIT        ;WAIT
        INC     @#YREG          ;STEP TO NEXT LINE
        BR      REP             ;GO DO THE REPLICATION
EXIT:   JMP     RESTR
;
;       CALL SC TO SET UP THE CURSOR
;
SC:     JSR     R4,SAVER
        MOV     #3,R3
SC10:   MOV     #32.,X
        MOV     #32.,Y          ;WRITE A MARK AT 32,32
        .CALL   DLINE,<ZERO,Y,X,TEN,ONE,ZERO>
        MOV     #9.,R4
SC20:   ADD     #2,Y
        .CALL   DLINE,<ZERO,Y,X,ONE,ONE,ZERO>
        SOB     R4,SC20
        SOB     R3,SC10         ;REPEAT TO MAKE IT WHITE ENOUGH
        MOV     #3,R3
SC30:   MOV     #973.,Y
        MOV     #992.,X         ;WRITE A MARK AT 992,992
        MOV     #9.,R4
SC40:   .CALL   DLINE,<ZERO,Y,X,ONE,ONE,ZERO>
        ADD     #2,Y
        SOB     R4,SC40
        MOV     #973.,X
        .CALL   DLINE,<ZERO,Y,X,TEN,ONE,ZERO>
        SOB     R3,SC30
        .CALL   TYPE,<M3,ZERO>  ;TELL OPERATOR TO MOVE CURSOR
SC50:   .CALL   PARAM,<MP,PAR,FIVE>
        JSR     R5,ULDR         ;CHECK FOR REQUESTED CURSOR MOVE
        BR      SC50            ;CURSOR WAS MOVED
        MOV     @#GSYCP,YZ      ;STORE Y ZERO ADJUSTMENT
```

```
        MOV     @#GSXCP,XZ          ;STORE X ZERO ADJUSTMENT
        .CALL   TYPE,<M4,ZERO>      ;MOVE TO LOWER RIGHT
SC60:   .CALL   PARAM,<NP,PAR,FIVE>
        JSR     R5,ULDR
        BR      SC60                ;CURSOR WAS MOVED
        MOV     @#GSYCP,YD
        SUB     YZ,YD               ;STORE Y DELTA
        MOV     @#GSXCP,XD
        SUB     XZ,XD
        BIC     #176000,YZ
        BIC     #176000,XZ
        .CALL   UPARAM,<FOUR,YZ,INTPH>  ;SAVE THE ADJUSTMENTS ON DISK
        JMP     RESTR
;
RCA::   .CALL   PPARAM,<NP,YZ,FOUR,INTPH>       ;READ ADJSTMNTS FROM DISK
        RTS     R5
;
;       CALL CURSOR(YCP,XCP[,LINE,SAMP])
;
CURSOR::JSR     R4,SAVER
        MOV     @#GSYCP,R0
        BIC     #176000,R0
        SUB     YZ,R0               ;ADJUST THE READING
        MUL     #960.,R0
        DIV     YD,R0
        ADD     #32.,R0             ;AY=(Y-YZ)*960/YD+32
        ASL     R1
        CMP     R1,YD
        BLT     C20
        INC     R0                  ;ROUND UP
C20:    MOV     @#GSXCP,R2
        BIC     #176000,R2
        SUB     XZ,R2               ;ADJUST THE X READING
        MUL     #960.,R2
        DIV     XD,R2
        ADD     #32.,R2
        ASL     R3
        CMP     R3,XD
        BLT     C40
        INC     R2                  ;ROUND UP
C40:    MOV     R0,@2(R5)           ;STORE YCP
        MOV     R2,@4(R5)           ;STORE XCP
        BIT     #4,@R5
        BEQ     CEX                 ;BR IF NOT 4 PARAMETERS
        ASR     R0
        INC     R0
        MOV     R0,@6(R5)           ;LINE=YCP/2+1
        ASR     R2
        INC     R2
        MOV     R2,@10(R5)          ;SAMP=XCP/2+1
CEX:    JMP     RESTR
;
MCU::   SUB     #2,@#GSYCP          ;CALL MCU TO MOVE CURSOR UP
        RTS     R5
MCD::   ADD     #2,@#GSYCP          ;CALL MCD TO MOVE CURSOR DOWN
        RTS     R5
MCL::   SUB     #2,@#GSXCP          ;CALL MCL TO MOVE CURSOR LEFT
        RTS     R5
MCR::   ADD     #2,@#GSXCP          ;CALL MCR TO MOVE CURSOR RIGHT
        RTS     R5
;
UDLR::  MOV     @2(R5),PAR          ;CALL UDLR(PAR)  EXTERNAL CALL
        BR      UL20
                                    ;CALL ULDR  INTERNAL CALL
ULDR:   TST     NP                  ;CHECK FOR U,L,D, OR R TYPED
        BNE     UL20                ;BR IF A LETTER WAS TYPED
        TST     (R5)+               ;SET FOR NO TYPEIN RETURN
        RTS     R5
UL20:   CMPB    PAR,#'U
        BNE     UL30                ;BR IF NOT A U
        DEC     @#GSYCP             ;MOVE CURSOR UP ONE STEP
UL30:   CMPB    PAR,#'D
        BNE     UL40
        INC     @#GSYCP             ;MOVE CURSOR DOWN ONE STEP
UL40:   CMPB    PAR,#'L
        BNE     UL50
```

```
        DEC     @#GSXCP         ;MOVE CURSOR LEFT ONE STEP
UL50:   CMPB    PAR,#'R
        BNE     UL60
        INC     @#GSXCP ,MOVE CURSOR RIGHT ONE STEP
UL60:   RTS     R5              ;TYPEIN RETURN
;
ZERO:   .WORD   0,0,0,0,0
ONE:    .WORD   1
FOUR:   .WORD   4
FIVE:   .WORD   5
TEN:    .WORD   10.
INTPH:  .WORD   7               ;INT1 PHASE NUMBER
PAR:    .BLKW   5
        X=PAR
        Y=PAR+2
        NP=PAR+4
        .NLIST  BEX
M3:     .ASCIZ  / MOVE CURSOR TO UPPER LEFT MARK/
M4:     .ASCIZ  / MOVE CURSOR TO LOWER RIGHT MARK/
        .EVEN
YZ:     .WORD   32.
YD:     .WORD   960.
XZ:     .WORD   32.
XD:     .WORD   960.
        .BLKB   DWAIT+1500-.
        .END
```

```
        .TITLE  MCISUB - MCI SUBROUTINES
;               CALMS VERSION
        .MCALL   CALL,.PAUSE
        XCPR==164040
        YCPR==164042
        FCPR==164044
        SMSC==164046
        IEAPD==164050
        SPRD==164074
        FOCP==164076
        LITES==164134
        LEDS==164136
        SRSTA==300              ;SEARCH START INTERRUPT ADDRESS
        SRHAA==304              ;SEARCH HALT
        SRRSA==310              ;SEARCH RESUME
        EDSTA==314              ;EDIT START
        ACSPA==320              ;ACCEPT SPREAD
        RJSPA==324              ;REJECT SPREAD
        NXSPA==330              ;NEXT SPREAD
        LASPA==334              ;LAST SPREAD
        EDENA==340              ;EDIT END 9
        FOCA==344               ;FOCUS 10
        KYRQA==350              ;KBD REQUEST 11
        SDFPA==374              ;SPRD/FOCUS DATA READY INTERRUPT ADDR
        ;
        ;CURRENT ORIGIN IS 50500
        ;
CMCI::  BIS     #40000,@#SMSC   ;CAPTURE MCI
        RTS     R5
RMCI::  BIC     #40000,@#SMSC   ;RELEASE MCI
        RTS     R5
XWAIT:: BIT     #4000,@#SMSC
        BNE     XWAIT
        RTS     R5
YWAIT:  BIT     #200,@#SMSC
        BNE     YWAIT
        RTS     R5
FWAIT:  BIT     #10,@#SMSC
        BNE     FWAIT
        RTS     R5
;
IXYABS::.CALL   XWAIT           ;CALL IXYABS(X,Y) TO INITIATE ABS MOVE
        .CALL   YWAIT
        .CALL   CMCI
        MOV     @2(R5),X
        BPL     IXY20
```

```
        NEG     X               ;MAKE X POSITIVE
IXY20:  MOV     @4(R5),Y
        BPL     IXY30
        NEG     Y               ;MAKE Y POSITIVE
IXY30:  SUB     X,@#XCPR        ;INITIATE MOVE TO X,Y
        SUB     Y,@#YCPR
        RTS     R5
;
IXREL:: .CALL   XWAIT           ;CALL IXREL(XDEL) TO INITIATE X MOVE
        .CALL   CMCI
        MOV     @2(R5),@#XCPR
        RTS     R5
IYREL:: .CALL   YWAIT
        .CALL   CMCI
        MOV     @2(R5),@#YCPR
        RTS     R5
IFREL:  .CALL   FWAIT           ;CALL IFREL(FDEL) TO INITIATE FOCUS MOVE
        .CALL   CMCI
        MOV     @2(R5),@#FCPR
        RTS     R5
CFOC::  MOV     @#FOCP,TEMP     ;CALL CFOC(F) TO CALCULATE FOCUS
        CLR     @2(R5)
        MOVB    TEMP+1,@2(R5)
        CLRB    TEMP+1
        ADD     TEMP,@2(R5)     ;FOCUS=F1+F2
        RTS     R5
IXCPR:  BIS     #400,@#SMSC     ;INITIALIZE XCPR
        RTS     R5
IYCPR:  BIS     #20,@#SMSC
        RTS     R5
IFCPR:  BIS     #1,@#SMSC
        RTS     R5
;
LED::   JSR     R4,SAVER        ;CALL LED(CODE,VAL)
        MOV     @2(R5),R0       ;CODE TO R0
        ASH     #13.,R0         ;SHIFT TO HI ORDER 3 BITS
        MOV     @4(R5),R1       ;VALUE TO R1
        BIC     #177000,R1
        ADD     R1,R0
        MOV     R0,@#LEDS       ;OUTPUT DISPLAY
        JMP     RESTR
;
MFST::  JSR     R4,SAVER        ;CALL MFST(MAGN,FPOS)
        MOV     @#IEAPD,R0      ;FLTR/MAGN POS REG TO R0
        MOV     R0,R1           ;ALSO R1
        ASH     #-10.,R0
        BIC     #177770,R0      ;MASK OUT MAGN
        MOVB    LENS(R0),MAGN   ;STORE MAGN
        CLR     FSTEP           ;CLEAR TOP BYTE
        MOVB    FSTA3(R0),FSTEP ;STORE FOCUS STEP SIZE
        MOVB    FLTA8(R0),FLAST ;STORE LAST STEP SIZE
        MOVB    XATA8(R0),R2    ;ADJUSTMENT FOR NON-CENTRALITY
        MOV     R2,XADJ
        MOVB    YATA8(R0),R2    ;ADJUSTMENTS ARE FOR 63 AND 100
        MOV     R2,YADJ         ;RELATIVE TO 40
        MOV     MAGN,@2(R5)
        ASH     #-13.,R1        ;SHIFT FILTER CODE
        BIC     #177770,R1
        MOV     R1,@4(R5)
        MOV     R1,FPOS
        .CALL   LED,<OMLED,MAGN>        ;DISPLAY MAGNIFICATION
        JMP     RESTR
;
SORTQ:  JSR     R4,SAVER        ;SUBROUTINE TO SORT THE QUEUE
        MOV     #SPR,R3         ;R3 AND R4 POINT TO LOW QUEUE POSITIONS
        MOV     #SPQ,R4         ;THE CURRENT HI RATING IS MOVED HERE
        MOV     NSP,NSR         ;INITIALIZE # SPREADS REMAINING
SQ20:   CLR     R0              ;R0 HAS MAX RATING
        MOV     R3,R1           ;USE R1 TO EXAMINE REMAINING SPRDS
        MOV     NSR,R2
        BEQ     SQEX            ;BR IF NO SPREADS REMAIN
SQ30:   CMPB    (R1)+,R0        ;EXAMINE A RATING
        BLE     SQ40            ;BR IF NOT GREATER THAN MAX
        MOVB    -(R1),R0        ;STORE NEW MAX
        MOV     R1,REG1         ;SAVE R1
```

```
        INC     R1
SQ40:   SOB     R2,SQ30         ;BR IF MORE TO EXAMINE
        DEC     NSR
        TST     R0
        BEQ     SQEX            ;BR IF ALL HAVE BEEN SORTED
        MOV     REG1,R1
        MOV     R1,R2           ;R2 WILL HAVE POSITION IN SPQ
        SUB     #SPR,R2
        ASH     #2,R2
        ADD     #SPQ,R2
        MOVB    @R1,R0
        MOVB    @R3,@R1         ;SWITCH RATINGS
        MOVB    R0,(R3)+
        MOV     @R2,R0          ;SWITCH X AND Y VALUES
        MOV     @R4,(R2)+
        MOV     R0,(R4)+
        MOV     @R2,R0
        MOV     @R4,@R2
        MOV     R0,(R4)+        ;R3 AND R4 ARE UPDATED
        BR      SQ20            ;GO GET THE NEXT HIGHEST
SQEX:   CLR     @R4             ;MARK END OF QUEUE
        CLRB    @R3             ;MARK END OF RATINGS
        JMP     RESTR
;
MAGN:   .WORD   0
FPOS:   .WORD   0
LENS:   .BYTE   0,40.,64.,100.,101.,4,63.,0
FSTAB:  .BYTE   1,15.,10.,0.,0.,25.,0.,1
FLTAB:  .BYTE   1,0.,5.,2,2.,15.,4,1
XATAB:  .BYTE   0,0,0,5,0,0,9.,0        ;XADJ FOR 63 AND 100 REL TO 40
YATAB:  .BYTE   0,0,0,3,0,0,2,0         ;YADJ
XADJ:   .WORD   .-.
YADJ:   .WORD   .-.
FSTEP:  .WORD   .-.
FLAST:  .WORD   .-.
X:      .WORD   0
Y:      .WORD   0
SNLED:  .WORD   0               ;CODE FOR SPREAD NUMBER DISPLAY
SQLED:  .WORD   1               ;SCAN QUEUE
AQLED:  .WORD   2               ;ANALYSIS QUEUE
OMLED:  .WORD   3               ;OBJ MAGN
HQLED:  .WORD   4               ;HARD COPY QUEUE
LKLED:  .WORD   5               ;LAST KEY
TEMP:   .WORD   0
NSR:    .WORD   .-.
REG1:   .WORD   .-.
        .BLKB   CMCI+1300-.     ;MAKE LENGTH CONSTANT
        .END
        .TITLE  RPARAM  READ AND WRITE PARAMETERS UNDER CALMS
        .MCALL  .CALL
        BUFSIZ=60
;
APHASE: MOV     @2(R5),NPHASE   ;ASSIGN NEXT PHASE  CALL APHASE(N)
        RTS     R5
;
WPARAM: JSR     R4,SAVER        ;CALL WPARAM(NP,PAR,PNUM)
        MOV     @2(R5),R0       ;NP
        MOV     4(R5),WP20+12   ;PAR LOCATION
        MOV     @6(R5),R1       ;PNUM
        MOV     R1,PREC
        ASL     R1
        ADD     #NPTAB-2,R1
        MOV     R0,@R1          ;STORE NP
WP20:   .CALL   WRITE,(PMVB,PREC,.-.)   ;WRITE THE PARAMETER DATASET
        JMP     RESTR
;
RPARAM: JSR     R4,SAVER        ;CALL RPARAM(NP,PAR,NPMAXI,PNUM)
        MOV     PNUM,R0
        BIT     #4,@R5
        BEQ     RP10            ;BR IF NOT 4 PARAMETERS
        MOV     @10(R5),R0      ;USE PNUM FROM PARAMETER LIST
RP10:   MOV     R0,PREC
        ASL     R0
        ADD     #NPTAB-2,R0
```

```
        MOV     @R0,@2(R5)          ;STORE NP FOR THIS PHASE
        BEQ     RP40                ;SKIP THE READ IF NP=0
        CMP     @R0,@6(R5)
        BHI     RPERR               ;BR IF NP GT NPMAX
        MOV     4(R5),RP20+14
        MOV     @R0,PMVB+BUFSIZ     ;SET UP TO READ NP WORDS
        ASL     PMVB+BUFSIZ
RP20:   .CALL   READ,<PMVB,PREC,INDEX,.-.>      ;READ THE PARAMETER DS
RP40:   JMP     RESTR
RPERR:  MOV     PNUM,-(SP)          ;TOO MANY PARAMETERS
        MOV     #1770,-(SP)
        IOT                         ;PRINT F370
;
PREC:   .WORD   .-.
INDEX:  .WORD   .-.
        .END


        .TITLE  SCAN - SDS DATA CAMERA DRIVER
        ;
        ;CALMS VERSION  CALL SCAN(DUNIT,FILPEX)
        ;THIS VERSION USES MYIO IN DOUBLE BUFFERING 24
        ;TY VERTICAL LINES AT A TIME FROM CAMERA TO A DISK DATA SET
        ;IN NON-INTERRUPT MODE.
        ;THE PICTURE IS DISPLAYED ON THE GRAY SCALE.
        ;SECTOR HISTOGRAMS ARE GENERATED AS THE PIXELS ARE SCANNED.
        ;THRESHOLDS ARE FOUND AFTER EACH GROUP OF SECTORS AND TYPED
        ;OUT WHILE THE NEXT ROW OF SECTORS IS SCANNED IF SW1 IS UP.
        ;THE SCAN AREA IS VARIABLE WITH A MAXIMUM OF 512 LINES AND
        ;400 SAMPLES PER LINE.
        ;
        .GLOBL OPEN,GET,PUT,CLOSE,PARAM,QPRINT,PLABEL,PARBUF
        .GLOBL  AFILE,SCAN
        .MCALL  PARAM,.EXIT,.CVTDT,.CALL,.PAUSE
        .PARAM
        .NLIST  BEX
        ;
        LF=12
        CR=15
        COMD=164020
        STAT=164020
        XREG=164022
        YREG=164024
        ZREG=164026
        XJREG=164030            ;X JOYSTICK REGISTER
        YJREG=164032            ;Y JOYSTICK REGISTER
        ;
SCAN:   MOV     R5,-(SP)        ;SAVE R5
        MOV     2(R5),S100+10   ;CALL SCAN(DUNIT,FILPEX) STORE DUNIT
        MOV     4(R5),S100+12   ;STORE CALMS DATA SET NAME
        MOV     #2,UIC          ;AND UIC OF [2,2]
S100:   .CALL   AFILE,<BUF,.-.,.-.,UIC,UIC>     ;ASSIGN DEFAULT FILE
        .CALL   OPEN,<BUF,SIZE,ONE,ONE,LNAME>   ;OPEN DISK DATA SET
S102:   .CALL   TYPE,<M1,ZERO>
TFCI:   BIT     #400,@#IEAPD    ;TEST IF STILL FOCUSING
        BEQ     TFCI            ;BR IF SO
        .CALL   RMCI            ;RELEASE MCI TO OPERATOR
        .CALL   PARAM,<NPAR,PAR,NPMAX>  ;READ LABEL
        MOV     SOURCE,L+12.    ;MOVE INFO INTO LABEL
        MOV     PANUM,L+14.
        MOV     SLNUM,L+16.
        MOV     @#XCPR,L+18.
        MOV     @#YCPR,L+20.
        .CALL   OUTCON,<SOURCE,L+81.,TWO>
        .CALL   MVL,<PANUM,L+92.,LPANUM>        ;MOVE PANUM INTO LABEL
        MOVB    PASEX,L+103.
        .CALL   MVL,<SLNUM,L+112.,LSLNUM>
        TST     NPAR
        BEQ     S106            ;BR IF NO PARAMETERS (USE OLD LABEL)
        CMP     NPAR,#2
        BNE     S104            ;BR IF NOT TWO PARAMETER WORDS
        CMP     #"PQ,PAR
        BNE     NOTPQ           ;BR IF NOT PRINT Q REQUEST
        .CALL   PRINTQ,<L+72.,SPR,SPQ>
```

```
        JMP     S102
NOTPQ:  CMP     #"A ,PAR
        BNE     NOTAB           ;BR IF NOT ABORT
        .CALL   APHASE,ZERO
        JMP     S309
NOTAB:  CMP     #"Z ,PAR
        BNE     S103            ;BR IF NOT ZERO QUEUE REQUEST
        CLR     NSCAN           ;ZERO NSCAN
        .CALL   APHASE,ZERO     ;AND ABORT THIS SCAN
        JMP     SEXIT
S103:   CMP     #"EX,PAR
        BNE     S104            ;SCAN IF EX WAS NOT TYPED
        JMP     SEXIT
S104:   CMP     #"DS,PAR
        BNE     S105            ;BR IF NOT DUMMY SCAN
        INC     DFLAG           ;SET DFLAG
        BR      S106
S105:   MOV     #PARBUF,R1
        MOV     #L+217.,R2      ;ADD ANOTHER LABEL WITH MISC ID
        MOV     #69.,R3         ;MAX OF 69 CHARACTERS IN LABEL
MLAB:   MOVB    (R1)+,R0
        CMP     R0,#CR
        BEQ     ELAB            ;BR IF END OF LABEL (CR)
        MOVB    R0,(R2)+        ;STORE LABEL CHARACTER
        SOB     R3,MLAB
        BR      S106
ELAB:   MOVB    #40,(R2)+       ;PAD REST OF LABEL WITH BLANKS
        SOB     R3,ELAB
S106:   JSR     PC,PPAR         ;PROCESS PARAMETERS
        .CALL   OUTCON,<XCPR,L+127.,FOUR>
        .CALL   OUTCON,<YCPR,L+135.,FOUR>
        .CALL   MVL,<L+124.,M2+15.,FOUR>
        .CALL   MVL,<L+132.,M2+22.,FOUR>
        .CALL   TYPE,M2
        .CVTDT  #0,@L+145.      ;STORE DATE IN LABEL
        .CVTDT  #1,@L+155.      ;STORE TIME IN LABEL
        TST     DFLAG
        BNE     S108            ;NO OUTPUT LABEL IF DUMMY SCAN
        .CALL   PLABEL,<BUF,SPAR,L>     ;OUTPUT LABEL
S108:   .CALL   DCLEAR
        .CALL   DCLEAR          ;CLEAR THE GRAY SCALE
S110:   CLR     LINE            ;LINE=0
        MOV     SL,X            ;INITIAL XCOUNT
        CLR     @#COMD          ;DISABLE PIXEL INTERRUPT
        CLR     GY              ;CLEAR GS LINE COUNTER
        MOV     #TTAB,TX
        MOV     #BTAB,BX
        JSR     PC,THEAD        ;TYPE HEADING
        CLR     SNUM            ;SECTOR NUMBER=0
LSEC:   MOV     LPS,SCTR
        .CALL   ZIA,<HIST,HDIM> ;ZERO HISTOGRAM COUNTS
EFLIN:  MOV     SS,Y            ;INITIAL Y
        MOV     X,@#XREG        ;SET LINE COUNT
        INC     LINE            ;INCREMENT MYIO LINE COUNT
        TST     DFLAG
        BNE     S115            ;BR IF DUMMY SCAN
        .CALL   PUT,<BUF,LINE,INDEX>    ;PREPARE STORAGE OF NEXT TV LINE
S115:   MOV     BUFF,R0         ;INIT BUFFER POINTER TO BUF+NS-1
OFLIN:  ADD     INDEX,R0        ;SET POINTER FOR NEXT LINE
        MOV     #HIST,R4        ;R4 HAS LOC OF HIST
        MOV     ISPS,R3         ;INITIAL SAMPLES PER SECTOR
        MOV     Y,@#YREG        ;SET PIXEL COUNT
        MOV     #COMD,R2        ;A(COMD-STATUS REGISTER) TO R2
        MOV     #3,@R2          ;GET FIRST PIXEL OF THIS FIELD
        TSTB    @R2
        BPL     .-2             ;WAIT UNTIL READY
        MOV     #300,@#PSW      ;SET PRIORITY 6 FOR THE REST OF THE FIELD
        BR      MOVB
;
SECTOR: MOV     SPS,R3          ;R3=SAMPLES PER SECTOR
PIXEL:  MOV     #3,@R2          ;PIXEL COMMAND
        TSTB    @R2
        BP      .-2             ;WAIT UNTIL READY
MOVB:   MOVB    @#XREG,R1       ;MOVE PIXEL INTO BUFFER
        BNE     NOTZE           ;BR IF NOT ZERO
```

```
        INC     R1              ;CONVERT 0 TO 1
NOTZE:  CMP     R1,#127.
        BNE     NOT127          ;BR IF NOT 127
        MOV     #126.,R1        ;CHANGE 127 TO 126
NOT127: MOVB    R1,@R0          ;STORE PIXEL IN BUFFER
        BIC     #1,R1
        ADD     R4,R1           ;HIST + PIXEL VALUE (0,2,4,...62)
        INC     @R1             ;INC COUNT FOR THIS VALUE
        SUB     #2,R0           ;DECREMENT POINTER
        SOB     R3,PIXEL        ;BR IF MORE PIXELS IN THIS SECTOR
        ADD     #128.,R4        ;STEP HISTOGRAM POINTER
HTEST:  CMP     R4,#HIST+1024.+.-.      ;HIST+NC*128
        BLO     SECTOR          ;BR IF MORE SECTORS
;
        BIT     #1,Y            ;TEST FOR EVEN OR ODD FIELD
        BGT     OFEND           ;BR IF END OF ODD FIELD
EFEND:  CLR     @#PSW           ;RETURN TO PRIORITY 0 AT END OF FIELD
        INC     Y               ;SET Y FOR ODD FIELD PIXELS
        TST     GY
        BEQ     EFMOV           ;BR IF FIRST LINE
        BIT     #10,@#SWR
        BNE     EFMOV           ;FOR QUICK LOOK, WRITE EVERY OTHER LINE
EFCALL: .CALL   DLINE,<.-.,GY,GX,NS,REPL,ZERO>  ;REPLICATE PREVIOUS LINE
        INC     GY
EFMOV:  MOV     BUFF,R0
        DEC     R0              ;SET BUFFER POINTER TO BUF+NS-2
        JMP     OFLIN           ;GO GET ODD FIELD PIXELS
OFEND:  CLR     @#PSW           ;RETURN TO PRIORITY 0 AT END OF FIELD
        ADD     #2,R0
        MOV     R0,OFCALL+6     ;STORE START OF CURRENT LINE
        MOV     R0,EFCALL+6     ;IN BOTH CALLS TO DLINE
OFCALL: .CALL   DLINE,<.-.,GY,GX,NS,REPL,ZERO>  ;WRITE TO GRAY SCALE
        INC     GY
        BIT     #10,@#SWR
        BEQ     5$              ;BR IF NOT QUICK LOOK
        INC     GY              ;STEP GY AGAIN
5$:     INC     X               ;INCREMENT X (LINE COUNT)
        DEC     SCTR
        BGT     NOTES           ;BR IF NOT END OF SECTOR
        JSR     PC,THRESH       ;CALC THRESHOLDS FOR THESE SECTORS
        CMP     X,EL
        BGE     FIN             ;BR IF FINISHED
        JMP     LSEC            ;GO START NEXT LINE SECTOR
JEFLIN: JMP     EFLIN
NOTES:  CMP     X,EL            ;TEST FOR END OF PICTURE
        BLT     JEFLIN          ;GO START NEXT LINE OF PIXELS
        JSR     PC,THRESH       ;CALC THRESH FOR LAST SECTORS
FIN:    MOV     #TDATA,R1
        TST     DFLAG
        BNE     S202
CPUT:   .CALL   PUT,<BUF,ZERO,INDEX>
        MOV     #BUF,R2
        ADD     INDEX,R2
        MOV     NS,R3
MTD:    MOVB    (R1)+,(R2)+     ;MOVE TDATA TO BUF
        SOB     R3,MTD
        CMP     R1,#TDATA+266.
        BLO     CPUT            ;BR IF MORE OF TDATA TO OUTPUT
S202:S300:
SEXIT:  .CALL   CLOSE,BUF
TSTR5:  MOV     (SP)+,R5        ;RESTORE R5
RTS:    RTS     R5              ;RETURN TO SUPERVISOR ***************
;
PPAR:   .CALL   TYPE,<M3,ZERO>  ;JSR PC,PPAR
        .CALL   PARAM,<NPAR,PAR,NPMAX>
        MOV     #PAR,R1
        CLR     NR
        CLR     NC
P10:    TST     NPAR
        BGT     P15             ;BR IF MORE PARAMETERS
        JMP     P150
P15:    MOV     (R1)+,R0        ;R0=PARAMETER WORD
        MOV     #NK,R2
        MOV     #KEY,R3
P20:    CMP     R0,(R3)+
```

```
        BEQ     P50             ;BR IF PARAMETER EQ KEYWORD
        SOB     R2,P20          ;BR IF MORE KEYWORDS
        CMP     NPAR,#4         ;NOT A KEYWORD, MAYBE AREA IS SPECIFIED
        BGE     P30             ;BR IF 4 WORDS LEFT
P25:    .CALL   TYPE,M4         ;PARAMETER ERROR
        BR      PPAR
P30:    CMP     R0,#MAXNL
        BGE     P25             ;BR IF SL TOO LARGE
        MOV     R0,SL
        BLT     P25             ;BR IF SL TOO SMALL
        MOV     (R1)+,R0        ;EL
        BLE     P25             ;BR IF EL TOO SMALL
        CMP     R0,#MAXNL
        BGT     P25             ;BR IF EL TOO LARGE
        MOV     R0,EL
        SUB     SL,R0
        BLE     P25             ;BR IF NL TOO SMALL
        MOV     R0,NL           ;NL=EL-SL
        MOV     (R1)+,R0        ;SS
        BLT     P25             ;BR IF SS TOO SMALL
        CMP     R0,#MAXNS
        BGE     P25             ;BR IF SS TOO LARGE
        BIC     #1,R0           ;MAKE SS EVEN
        MOV     R0,SS
        MOV     (R1)+,R0        ;ES
        BIC     #1,R0           ;ES MUST BE EVEN
        BLE     P25             ;BR IF ES TOO SMALL
        CMP     R0,#MAXNS
        BGT     P25             ;BR IF ES TOO LARGE
        SUB     SS,R0           ;NS=ES-SS
        BLE     P25             ;BR IF NS TOO SMALL
        MOV     R0,NS
        MOV     #512.,R3
        CLR     R2
        DIV     R0,R2
        MOV     R2,NLR          ;NLR=512/NS
        ADD     #BUF,R0
        DEC     R0
        MOV     R0,BUFF         ;BUFF=BUF+NS-1
        SUB     #4,NPAR         ;NPAR=NPAR-4
        BR      P10
P50:    TST     (R1)+           ;STEP OVER SECOND WORD
        ADD     #NK+NK-2,R3     ;LOC FOR THIS KEYWORD
        MOV     @R3,PC          ;GO THERE
P60:    MOV     (R1)+,DPER
        MOV     #100.,BPER
        SUB     DPER,BPER       ;BPER=100-DPER
P63:    SUB     #3,NPAR         ;NPAR=NPAR-3
        BR      P10
P70:    MOV     @R1,DBEG        ;DBEG
        MOV     (R1)+,BKSIZ
        ASR     BKSIZ
        DEC     BKSIZ           ;BKSIZ=DBEG/2-1
        MOV     #62.,DTSIZ
        SUB     BKSIZ,DTSIZ     ;DTSIZ=62-BKSIZ
        BR      P63
P80:    MOV     (R1)+,NR        ;NR
        BR      P63
P90:    MOV     (R1)+,NC        ;NC
        BR      P63
P95:    INC     @FLAG           ;QUICK LOOK (WHILE SCANNING)
        SUB     #2,NPAR
        BR      P10
P100:   MOV     @#YJREG,JPAR+4  ;JOYSTICK
        MOV     @#XJREG,JPAR    ;STORE SL AND SS
        BIC     #177000,JPAR
        .CALL   TYPE,<M5,ZERO>  ;REQUEST MOVE TO LOWER RIGHT
        .CALL   PARAM,<NPAR,PAR,NPMAX>
        MOV     @#YJREG,JPAR+6  ;STORE ES
        MOV     @#XJREG,JPAR+2  ;EL
        BIC     #177000,JPAR+2
        MOV     #JPAR,R1
        MOV     (R1)+,R0
        MOV     #4,NPAR
```

```
        JMP     P30             ;GO PROCESS AREA PARAMETERS
;
P150:   TST     NR              ;DONE WITH PARAMETERS
        BGT     P160            ;BR IF NR WAS A PARAMETER
        MOV     NL,R0
        ADD     #32.,R0
        ASH     #-6,R0
        BGT     P155            ;BR IF NL GT 31
        INC     R0              ;NR=1
P155:   MOV     R0,NR           ;NR=(NL+32)/64
P160:   TST     NC
        BGT     P170            ;BR IF NC WAS A PARAMETER
        MOV     NS,R0
        ADD     #32.,R0
        ASH     #-6,R0
        BGT     P165            ;BR IF NS GT 31
        INC     R0              ;NC=1
P165:   MOV     R0,NC           ;NC=(NS+32)/64
P170:   MOV     NL,R1
        ADD     NR,R1
        DEC     R1
        CLR     R0
        DIV     NR,R0
        INC     R0
        BIC     #1,R0           ;MAKE LPS EVEN
        MOV     R0,LPS          ;LPS=(NL+NR-1)/NR
        MOV     NS,R1
        CLR     R0
        DIV     NC,R0
        BIC     #1,R0           ;MAKE IT EVEN
        MOV     R0,SPS2         ;SPS2=NS/NC  SPS FOR 2 FIELDS
        ASR     R0
        MOV     R0,SPS          ;SPS FOR ONE FIELD
        MOV     NC,R1
        DEC     R1
        MUL     SPS,R1
        MOV     NS,R0
        ASR     R0
        SUB     R1,R0           ;ISPS=NS/2-(NC-1)*SPS
        MOV     R0,ISPS
        MOV     NC,R1
        ASH     #7,R1
        ADD     #HIST,R1        ;HIST+NC*128
        MOV     R1,HTEST+2
        SUB     #128.,R1
        MOV     R1,T05+2
        RTS     PC
;
;
;
THRESH:
        MOV     #MSG+3,T50+10
        MOV     #MSG+6,T60+10
T05:    MOV     #HIST+896.+-.,R4        ;HIST +(NC-1)*128
T10:    JSR     PC,SMOOTH
        JSR     PC,TSUB         ;FIND BACK AND DATA
        MOV     DPER,R1
        MUL     DATA,R1
        MOV     BPER,R3
        MUL     BACK,R3
        ADD     R3,R1
        ADD     #50.,R1
        CLR     R0
        DIV     #100.,R0        ;ITHR=(DPER*DATA+(100-DPER)*BACK+50)/100
        MOV     DATA,R1
        SUB     BACK,R1
        CMP     R1,#8.          ;CHECK FOR SMALL DIFFERENCE BETWEEN D AND B
        BGT     T20             ;BR IF OK
        MOV     BKSIZ,R0        ;ITHR=DBEG/2  (UNDIVIDED NUCLEUS)
T20:    TST     DATA
        BGT     T30
        MOV     #127.,R0        ;ITHR=127 IF NO DATA IN SECTOR
T30:    TST     BACK
        BGT     T40             ;BR IF BACK OK
        CMP     BX,#BTAB        ;SEE IF FIRST SECTOR
        BEQ     T40
```

```
        MOV     BX,R1           ;USE BACK FROM PREVIOUS SECTOR
        MOV     -(R1),BACK
T40:    MOV     R0,@TX
        MOV     R0,ITHR
        TST     DATA
        BGT     T45
        CLR     ITHR            ;ITHR=0 IF NO DATA
T45:    MOV     BACK,@BX        ;STORE IN TTAB AND BTAB
        ADD     #2,TX
        ADD     #2,BX           ;INCREMENT POINTERS
T50:    .CALL   OUTCON,<ITHR,-1,FOUR>
        ADD     #7,T50+10
T60:    .CALL   OUTCON,<BACK,-1,THREE>
        ADD     #7,T60+10
        SUB     #128.,R4
        CMP     R4,#HIST
        BHIS    T10             ;BR IF MORE HISTOGRAMS TO ANALYZE
        SUB     #6,T60+10
        CLRB    @T60+10
        INC     SNUM
        .CALL   OUTCON,<SNUM,M0+2,THREE>
        ADD     NC,SNUM
        DEC     SNUM
        MOVB    #'-,M0+3
        .CALL   OUTCON,<SNUM,M0+5,TWO>
        BIT     #2,@#SWR
        BEQ     T70             ;BR IF SW 1 DOWN
        .CALL   TYPE,M0
T70:    RTS     PC
;
;
;
THEAD:  MOV     NC,R1           ;JSR PC,THEAD  SET UP NC HEADINGS
        MOV     #MSG,R2
TH10:   MOV     #SHEAD,R3
        MOV     #7,R4
TH20:   MOVB    (R3)+,(R2)+
        SOB     R4,TH20         ;MOVE A SECTOR HEADING TO MSG
        SOB     R1,TH10         ;BR IF MORE SECTORS
        CLRB    @R2
        MOV     #6,R4
        MOV     #M0,R2
        MOV     #FHEAD,R3       ;FINAL HEADING
TH33:   MOVB    (R3)+,(R2)+
        SOB     R4,TH30
        BIT     #2,@#SWR
        BEQ     TH70            ;BR IF SW 1 DOWN
        .CALL   TYPE,M0
TH70:   RTS     PC
;
SMOOTH: MOV     R4,-(SP)        ;JSR PC,SMOOTH   SAVE R4
        MOV     #HIS+2,R3
        MOV     #62.,R2
SM20:   MOV     (R4)+,R0        ;HIS(I)=HIST(I-1)+HIST(I)+HIST(I+1)
        ADD     @R4,R0
        ADD     2(R4),R0
        MOV     R0,(R3)+
        SOB     R2,SM20
        MOV     (SP)+,R4
        RTS     PC
;
;       JSR     PC,TSUB
TSUB:   MOV     #HIS,R0         ;R0=BACK=HIS+0
        MOV     #10,R1          ;R1=MAX1=10
        MOV     BKSIZ,R2        ;BACK RANGE IS NOMINALLY 2-48
        MOV     #HIS+2,R3
TS40:   CMP     R1,(R3)+
        BGE     TS45            ;BR IF MAX1 GE HIS(I)
        MOV     -(R3),R1        ;MAX1=HIS(I)
        MOV     R3,R0           ;R0=HIS+I
        TST     (R3)+
TS45:   SOB     R2,TS40         ;BR IF MORE TO SEARCH
        SUB     #HIS,R0
        MOV     R0,BACK         ;STORE BACK
;
        MOV     #HIS,R0
```

```
        MOV     #4,R1
        MOV     DTSIZ,R2        ;DATA RANGE IS NOMINALLY FROM 50-124
TS50:   CMP     R1,(R3)+
        BGE     TS60            ;BR IF MAX GE HIS(I)
        CMP     -2(R3),-4(R3)   ;LOOK FOR RELATIVE MAXIMUM ON LEFT SIDE
        BLT     TS60            ;BR IF NOT
        MOV     -(R3),R1
        MOV     R3,R0           ;R0=HIS+I
        TST     (R3)+
TS60:   SOB     R2,TS50
        SUB     #HIS,R0
        MOV     R0,DATA         ;STORE DATA
        RTS     PC
;
;
;
        MAXNL=512.
        MAXNS=480.
        NK=6
KEY:    .ASCII  /DPDBNRNCQLJ /
        .WORD   P60,P70,P80,P90,P95,P100
SL:     .WORD   8.              ;STARTING LINE
EL:     .WORD   506.            ;ENDING LINE
SS:     .WORD   0               ;STARTING SAMPLE
DBEG:   .WORD   50.             ;DATA BEGIN
SPS:    .WORD   30.             ;SAMPLES PER SECTOR OF A FIELD
ISPS:   .WORD   30.             ;INITIAL SPS
BKSIZ:  .WORD   24.             ;DBEG/2-1
DTSIZ:  .WORD   38.             ;62-BKSIZ
SIZE:   .WORD   12288.          ;SIZE OF EACH 24-LINE BUFFER
SCTR:   .WORD   .-.
HDIM:   .WORD   512.            ;HIST DIMENSION (512 WORDS)
SPACE:  .WORD   40
EJECT:  .WORD   61
UIC:    .WORD   2               ;DEFAULT UIC IS 2,2
SYTY:   .WORD   70.
ZERO:   .WORD   0
ONE:    .WORD   1               ;CONSTANT
TWO:    .WORD   2
THREE:  .WORD   3
FOUR:   .WORD   4
FIVE:   .WORD   5
X:      .WORD   .-.
Y:      .WORD   .-.
LINE:   .WORD   .-.             ;LINE NUMBER TO PUT SUBROUTINE
QFLAG:  .WORD   0               ;FLAG FOR QUICK LOOK (WHILE SCANNING)
DFLAG:  .WORD   0               ;FLAG FOR DUMMY SCAN
INDEX:  .WORD   56.+.-.         ;REL BUFR ADDR FROM PUT
NPAR:   .WORD   .-.
JPAR:   .BLKW   4               ;JOYSTICK PARAMETERS
PAR:    .BLKW   80.
NPMAX:  .WORD   80.
SPAR:
NL:     .WORD   498.            ;# LINES
NS:     .WORD   472.            ;# SAMPLES
        .WORD   7               ;BPE
NLR:    .WORD   1               ;NLR
        .WORD   512.            ;BLKSIZ
HIST:   .BLKW   512.            ;8 64 WORD HISTOGRAMS
HIS:    .BLKW   64.             ;SMOOTHED HISTOGRAM
TDATA:
NR:     .WORD   .-.             ;# ROWS OF SECTORS
NC:     .WORD   .-.             ;# COLUMNS OF SECTORS
LPS:    .WORD   63.             ;LINES PER SECTOR
SPS2:   .WORD   60.             ;SAMPLES PER SECTOR
TTAB:   .BLKW   64.
BTAB:   .BLKW   64.
DPER:   .WORD   60.             ;DATA PERCENT
BPER:   .WORD   40.             ;BACK PERCENT
TX:     .WORD   TTAB+.-.
BX:     .WORD   BTAB+.-.
BACK:   .WORD   .-.
DATA:   .WORD   .-.
ITHR:   .WORD   .-.
SNUM:   .WORD   .-.             ;SECTOR NUMBER
QY:     .WORD   .-.
```

```
GX:     .WORD   0
REPL:   .WORD   -1
N0:     .BLKB   80.
MSG=N0+6
L:      .BLKB   32.
        .BYTE   350,365,360,360 ;VICAR NL ' 500' IN EBCDIC
        .BYTE   360,364,367,364 ;VICAR NS ' 474' IN EBCDIC
        .BYTE   100,323,100,361 ;VICAR FORMAT ' L 1' IN EBCDIC
        .BLKB   26.
        .ASCII  /SC/
        .ASCII  / SOURCE **  PATIENT ********** M  SLIDE /
        .ASCII  /********  X=****  Y=*****      AC/
        .ASCII  / **-***-** **:**:**                /
        .REPT   4.
        .ASCII  /          /
        .ENDR
        .ASCII  /AC/
        .REPT   7
        .ASCII  /          /    ;SCAN ID
        .ENDR
        .ASCII  /AC/
        .REPT   7
        .ASCII  /          /    ;INT2 ID
        .ENDR
        .ASCII  /AL/
        .BLKB   152.
BUF:    .BLKB   24650.          ;TWO 24 LINE BUFFERS + MVB
BUFF:   .WORD   BUF+471.+.-.    ;BUF+NS-1
LNAME:  .ASCII  /SCN/           ;PICTURE FILE DESIGNATOR TO MVIO
SHEAD:  .ASCII  /  ST-SB/
FHEAD:  .ASCII  / SECTS/
M1:     .ASCIZ  / ENTER SCAN ID /
M2:     .ASCIZ  / SCANNING AT X=**** Y=****/
M3:     .ASCIZ  / ENTER PARAMETERS (SL,EL,SS,ES) /
M4:     .ASCIZ  / PARAMETER ERROR/ <LF><LF>
M5:     .ASCIZ  / MOVE JOYSTICK TO J2 /
        .EVEN
        .END    SCAN
```

```
C       ***** BINARY PICTURE GENERATOR ****
        SUBROUTINE BINARY(DUNIT,FILPEX)
        BYTE FILPEX(9)
      IMPLICIT INTEGER (A-Z)
        COMMON/C1/NR,NC,LPS,SPS,TTAB(64),BTAB(64),BPER
        COMMON/C1/SLO,SSO,NLO,NSO,NOS,B,MAXNOB
        COMMON/C1/MNAREA,MXAREA,MNEPT,MXEPT,MAXLEN,NW,TOBN,ISW1
        COMMON/C1/ WORD(4128),PIC(12344),PBUF(512)
        INTEGER PAR(20),KEY(6),SPAR(5),CTAB(30),NTAB(30)
        BYTE PIC,PMSG(22),PBUF
        DATA NKEY/6/
        DATA KEY/'BP','TO','AR','EP','LE','SK'/
        CALL SSWTCH(4,ISW4)
        IF(ISW4.EQ.1) CALL TIMER
        CALL SSWTCH(1,ISW1)
        IF(ISW1.EQ.1) CALL TYPE(' BINARY')
        CALL RPARAM(NPAR,PAR,20)
C NPAR WILL BE ZERO THE FIRST TIME BINARY IS RUN ON A SPREAD
        IF(NPAR.EQ.0) CALL TYPE(' STARTING ANALYSIS ON')
        CALL AFILE(PIC,DUNIT,FILPEX,2,2)
        CALL OPEN(PIC,6144,1,0,'SCN')
        CALL GLABEL(PIC,SPAR,INDEX)
        IF(NPAR.EQ.0) CALL TYPE(PIC(INDEX+73),64)
C               DEFAULT PARAMETERS
        B = 3
        MAXNOB = 85
        MNAREA = 32
        MXAREA = 2000
        MNEPT = 8
        MXEPT = 200
        SLO = 1
        MAXLEN = 99
        SSO = 1
```

```
      NLO = SPAR(1)
      NSO = MIN0(SPAR(2),511)
      CALL GET(PIC,NLO+1,I)
      CALL MVW(PIC(I+1),HR,133)
C
      CALL RPARAM(NPAR,PAR,20)
      I = -2
1     I = I + 1
2     I = I + 2
      IF(I.GT.NPAR) GOTO 20
      DO 5 K=1,NKEY
      IF(PAR(I).NE.KEY(K)) GOTO 5
      GOTO(2,12,13,14,15,16),K
5     CONTINUE
C
C PARAMETER ERROR
      PAUSE 1
      GOTO 20
12    TOBN = PAR(I+2)
      GOTO 1
13    I = I + 2
      MNAREA = PAR(I)
      MXAREA = PAR(I+1)
      GOTO 2
14    I = I + 2
      MNEPT = PAR(I)
      MXEPT = PAR(I+1)
      GOTO 2
15    MAXLEN = PAR(I+2)
      GOTO 1
16    B = PAR(I+2)
      GOTO 1
20    CONTINUE
      IF(ISW4.EQ.1) CALL TIMER
      B = (B+1)/2
      SPS2 = (SPS+1)/2
    MSAMPS = NLO - (HR-1)*LPS
      NW = NSO/32 + 1
      NWT = (NSO+31)/32
      NWI = NWT*16
C  *** BINARY PICTURE AREA(WORD) IS ASSUMED TO BE ZERO INITIALLY
C                NW = NUMBER OF WORDS OUT PER LINE
C                NWI = NUMBER OF WORDS IN PER LINE
      S = 0
      C = 0
C                CTAB(30) = COLUMN TABLE (CONTAINS COLUMN INDEX FOR WORD)
C                NTAB(30) = NUMBER OF SAMPLES OF WORD BELONGING TO THE
C                           CURRENT COLUMN
      DO 50 W=1,NWT
      CTAB(W) = C
      NTAB(W) = 16
      IF(C.EQ.NC-1) GOTO 50
      S = S + 16
      IF(S.LT.SPS2) GOTO 50
      S = S - SPS2
      NTAB(W) = 16 - S
      C = C + 1
50    CONTINUE
      IF(ISW4.EQ.1) CALL TIMER
C
    SI = 1
      WI = NW
      REC = 1
    ILPS = LPS
C
    DO 300 R=1,HR
    IF(R.EQ.HR) ILPS = MSAMPS
C
      DO 290 L=2,ILPS,2
      CALL GET(PIC,REC,PI)
      REC = 0
      CALL MVW(PIC(PI+1),PBUF,NWI)
      CALL GET(PIC,0,PI)
```

```
      S = 1
C     IF(ISW4.EQ.1) CALL TIMER
C
      IF(TOBN.GE.0) GOTO 250
      DO 200 W=1,NWT
      CALL QTHR(PBUF(S),WORD(WI+W),TTAB(CTAB(W)+SI),PIC(PI+S),NTAB(W))
200   S=S+32
C     IF(ISW4.EQ.1) CALL TIMER
      GOTO 290
C
250   CONTINUE
      DO 280 W=1,NWT
      CALL STHR(PBUF(S),WORD(WI+W),TTAB(CTAB(W)+SI),PIC(PI+S),NTAB(W))
280   S = S + 32
290   WI = WI + NW
C
  300 SI = SI + NC
C
      IF(NPAR.EQ.0) CALL TYPE('0')
      PAR(1)='LE'
      PAR(3)=90
      CALL WPARAM(3,PAR,2)
C WRITE PARAMETERS IN CASE OF RERUN
      CALL CLOSE(PIC)
      IF(ISW4.EQ.1) CALL TIMER
      CALL SEGMNT
      IF(ISW4.EQ.1) CALL TIMER
C
      END


      SUBROUTINE SEGMNT
      IMPLICIT INTEGER(A-Z)
      COMMON/C1/SPAR(133),SLO,SSO,NLO,NSO,NOB,B,MAXNOB
      COMMON/C1/MNAREA,MXAREA,MNPERM,MXPERM,MAXLEN,NW,TOBN,ISW1
      COMMON/C1/ WORD(4126),N,PERIM,YMIN,XMIN,YMAX,XMAX
      COMMON/C1/DIR(512),EBUF(29),EDGE(4096)
      COMMON/C1/ NK,LIP(60),SIP(60),FI
      INTEGER PAR(5)
      BYTE LABEL(512),M(6),WHITE(14)
      DATA PAR/512,1024,7,1,512/
      DATA LABEL/70*' ','S','C',70*' ','A','L',360*' '/
      DATA MAXN/1022/,DREC/2/
C  THE EDGE POINT DIRECTORY CONTAINS THE FOLLOWING FOR EACH OBJECT
C     DIR(DI) = FBW (FIRST BLOCK WRITTEN)
C     DIR(DI+1) = N (NUMBER OF END POINTS)
C        DIR(DI+2) = YMIN
C        DIR(DI+3) = XMIN
C        DIR(DI+4) = YMAX
C        DIR(DI+5) = XMAX
C  THE EDGE POINTS ARE GROUPED IN COORDINATE PAIRS REPRESENTING SEGMENTS
C        EDGE(E) = Y          EDGE(E+1) = X1
C      EDGE(E+2) = Y          EDGE(E+3) = X2
      CALL ITLA(0,WHITE,14)
      IF(TOBN.LT.0) CALL RPARAM(NP,NK,122,6)
C READ OLD VALUE OF FI
      NK=0
      MNAR = MNAREA/4
      MXAR = MXAREA/4
      MNEPT = MNPERM/2
      MXEPT = MXPERM/2
      MXLEN = MAXLEN/2
      CALL SSWTCH(1,ISW1)
      IF(ISW1.EQ.1) CALL TYPE(' SEGMNT')
      CALL SSWTCH(4,ISW4)
      IF(ISW4.EQ.1) CALL SPRINT(' SEGMNT')
      CALL ZIA(EBUF,28)
      CALL ZIA(DIR,510)
      CALL ZIA(EDGE,1024)
      CALL MVL(' EDGE FILE',LABEL(73),10)
      IF(TOBN.LT.0) GOTO 130
      CALL AFILE(EBUF,1,'PIC      ',5,5)
      CALL OPEN(EBUF,1024,0,1,'MV2')
      CALL PLABEL(EBUF,PAR,LABEL)
      CALL PUT(EBUF,5,1HD)
```

```
100     CONTINUE
C               NW = NUMBER OF WORDS ON A BINARY LINE
        REC = 3
        NWH = NW/2
      NW2 = NW*2
      NL = NLO/2
      NS = NSO/2
C           NOB = NUMBER OF OBJECTS
C             WI = WORD INDEX          EWI = ENDING WORD INDEX
C             EI = EDGE INDEX          DI = DIRECTORY INDEX
C             BI = BIT INDEX (=0,1,2,...,31)
        EWI = NW
      DI = 1
        NOB = 1
C             SCAN BINARY PICTURE (WORD) LINE-BY-LINE
C
      DO 200 L=1,NL
      WI = EWI + 1
      EWI = EWI + NW
      LOOP = 0
C
C             THE ROACH WILL SCAN LINE FOR OBJECTS (ONE-BITS)
C
  140 IF(ROACH(WI,BI,WORD,EWI,MASK).EQ.0) GOTO 200
      LOOP = LOOP + 1
        IF(LOOP.EQ.200) PAUSE 1
        EDGE(1) = L
      EDGE(2) = (NW-(EWI-WI+1))*16 + BI + 1
      CALL TURTLE(N,EDGE,WORD(WI),MASK,NW2)
        IF(N.EQ.0) GOTO 140
        N2 = 2*N
        IF(NOB.NE.TOBN) GOTO 141
        CALL ILIST(NOB,N,YMIN,XMIN,YMAX)
C       CALL PDUMP(EDGE,EDGE(N2),1)
141     CONTINUE
        IF(N.GE.255) GOTO 142
        CALL SORTIN(EDGE,N,SIND)
C       IF(NOB.EQ.TOBN) CALL PDUMP(EDGE,EDGE(N2),1)
        IF(SIND.EQ.0) GOTO 145
142     IF(N.LE.MAXN) GOTO 143
        CALL TYPE(' TOO MANY EDGES')
        CALL TYPE(' ')
        GOTO 2000
143     CONTINUE
        IF(ISW1.EQ.1) CALL TYPE('   SORT')
        IF(ISW4.EQ.1) CALL STIMER
        CALL SORT(EDGE,N)
        IF(ISW4.EQ.1) CALL TIMER
C           N = NUMBER OF EDGE POINTS
145     CALL ERASE(WORD,EDGE,AREA,N2,NW)
        IF(N.LT.MNEPT.OR.N.GT.MXEPT) GOTO 196
        IF(AREA.LT.MNAR.OR.AREA.GT.MXAR) GOTO 196
        IF(YMAX-YMIN.GE.MXLEN.OR.XMAX-XMIN.GE.MXLEN) GOTO 196
C
C             ENTER OBJECT INTO DIRECTORY
        IF(NK.GE.60.OR.TOBN.GE.0) GOTO 175
        NK=NK+1
        LIP(NK)=EDGE(1)+EDGE(1)
        SIP(NK)=EDGE(2)+EDGE(2)
C STORE NOB INFORMATION FOR QUICK COUNT OPTION
        Y=4*EDGE(1)
        X=4*EDGE(2)-14
        IF(X.LT.0) X=0
C WRITE AN ARROW BY THE OBJECT
        CALL DLINE(WHITE,Y,X,8,1,0)
        CALL DLINE(WHITE,Y,X,8,1,0)
        CALL SSWTCH(6,ISW6)
        IF(ISW6.EQ.1) GOTO 175
        CALL DLINE(WHITE,Y-4,X+8,2,1,0)
        CALL DLINE(WHITE,Y-4,X+8,2,1,0)
        CALL DLINE(WHITE,Y-2,X+10,2,1,0)
        CALL DLINE(WHITE,Y-2,X+10,2,1,0)
        CALL DLINE(WHITE,Y+2,X+10,2,1,0)
        CALL DLINE(WHITE,Y+2,X+10,2,1,0)
        CALL DLINE(WHITE,Y+4,X+8,2,1,0)
        CALL DLINE(WHITE,Y+4,X+8,2,1,0)
```

```
175     CONTINUE
        DIR(DI) = REC
        DIR(DI+1) = N
        DIR(DI+2) = MAX0(YMIN-B,1)
        DIR(DI+3) = MAX0(XMIN-B,1)
        DIR(DI+4) = MIN0(YMAX+B,NL)
        DIR(DI+5) = MIN0(XMAX+B,NS)
          NOB = NOB + 1
          DI = DI + 6
          IF(NOB.GT.MAXNOB) GOTO 201
C
          IF(TOBN.LT.0) GOTO 140
C DON'T WRITE IF QUICK COUNT OPTION
          DO 195 I=1,N2,512
          CALL WRITE(EBUF,REC,EDGE(I))
195       REC = REC + 1
        GOTO 140
C
196       CALL SSWTCH(4,ISW4)
          IF(ISW4.NE.1) GOTO 140
          CALL QPRINT(' OBJECT REJECTED')
          CALL ILIST(NOB,N,AREA,YMIN,XMIN)
          CALL ILIST(YMAX-YMIN,XMAX-XMIN,MXAR,MXEPT,MXLEN)
          GOTO 140
C
200       MAXN = MAXN + NWN
C
201       NOB=NOB-1
          IF(TOBN.LT.0) GOTO 220
          IF(DI.GT.1) CALL WRITE(EBUF,DREC,DIR)
          CALL WRITE(EBUF,1,SPAR)
          CALL CLOSE(EBUF)
220       IF(NOB.GT.0) GOTO 2000
C IF NO OBJECTS FOUND, TYPE MSG AND CALL INT1
          CALL TYPE(' NO OBJECTS FOUND; CHECK THRESHOLDS')
          CALL TYPE('0')
          CALL APHASE(7)
2000      CONTINUE
          IF(TOBN.GE.0) RETURN
          CALL MVL(' NC=**',M,6)
          CALL OUTCON(NK,M(6),2)
          CALL TYPE(M,6)
          CALL WPARAM(122,NK,6)
          CALL APHASE(7)
C WRITE NOB PARAMETERS AND CALL INT1
          END


          SUBROUTINE SKIRT
        IMPLICIT INTEGER(A-Z)
          COMMON/C1/SPAR(133),SLO,SSO,NLO,NSO,NOB,B,OPER
          COMMON/C1/DIR(512),SDIR(512)
          COMMON/C1/EBUF(56),EDGE(1024),SEGB(56),SEG(8192)
          COMMON/C1/SBUF(900),ESI(5)
          INTEGER PAR(5)
          BYTE EBUF,SEGB
          DATA MAXSB/900/,MAXDI/510/,S/1/,DI/1/
          DATA DREC/2/,IDREC/2/
C
C   THE SEGMENT DIRECTORY CONTAINS THE FOLLOWING FOR EACH OBJECT
C                 SDIR(DI) = BSI(BEGINNING SEGMENT INDEX)
C                 SDIR(DI+1) = ESI(ENDING SEGMENT INDEX)
C                 SDIR(DI+2) = YMIN
C                 SDIR(DI+3) = XMIN
C                 SDIR(DI+4) = YMAX
C                 SDIR(DI+5) = XMAX
C   THE SEGMENTS ARE STORED AS TRIPLETS
C           SEG(S) = Y
C           SEG(S+1) = X1
C           SEG(S+2) = X2
C    THE ROB DIRECTORY CONTAINS THE FOLLOWING FOR EACH OBJECT
C                 DIR(DI) = BACKGROUND
C                 DIR(DI+1) = THRESHOLD
C                 DIR(DI+2) = YMIN
```

```
C               DIR(DI+3) = XMIN
C               DIR(DI+4) = YMAX
C               DIR(DI+5) = XMAX
        CALL SSWTCH(1,ISW1)
        IF(ISW1.EQ.1) CALL TYPE(' SKIRT')
        CALL AFILE(EBUF,1,'PIC      ',5,5)
        CALL OPEN(EBUF,1024,0,0,'MV2')
        CALL AFILE(SEGB,5,'PIC      ',5,5)
        CALL OPEN(SEGB,1024,0,1,'MV5')
        CALL GLABEL(EBUF,PAR,IND)
        CALL MVL(' SEGMENT FILE',EBUF(IND+73),13)
        CALL PLABEL(SEGB,PAR,EBUF(IND+1))
        CALL PUT(SEGB,1,IND)
C               GET SHAL PARAMS
        CALL READ(EBUF,1,IND,SPAR)
        DPER = SPAR(133) - 5
        OREC = 2*((NOB+34)/85)+2
        CALL WRITE(SEGB,1,SLO)
      NL = NLO/2
        NS = NSO/2
      B2 = 2*B + 1
      SINC = MAXSB/B2
      MAXSB = SINC*B2
C
C           S = SEGMENT INDEX
C          SI = SEGMENT BUFFER INDEX
C
        DO 200 OBN=1,NOB
        IF(DI.NE.1) GOTO 30
        CALL READ(EBUF,IDREC,IND,DIR)
        IDREC = IDREC + 1
        CALL MVW(DIR,SDIR,512)
30      IREC = DIR(DI)
        N = DIR(DI+1)
        SDIR(DI) = S
        CALL INTERP(DI)
        NEND = 2*N
        NREC = (NEND+511)/512
C
        DO 130 L=1,NREC
        CALL READ(EBUF,IREC,IND,EDGE)
        IREC = IREC + 1
        EIN = MIN0(NEND,512)
C             ADD HORIZONTAL SKIRT TO SEGMENTS
        DO 49 E=2,EIN,4
        EDGE(E) = MAX0(EDGE(E)-B,1)
49      EDGE(E+2) = MIN0(EDGE(E+2) + B,NS)
C
        IF(L.NE.1) GOTO 60
        Y0 = EDGE(1)
      YBAR = Y0 - B
C           USE FIRST SEGMENT END POINT PAIR TO INITIALIZE SBUF
        X1 = EDGE(2)
        X2 = EDGE(4)
      SI = 1
      DO 50 I=1,B2
      SBUF(SI) = X1
      SBUF(SI+1) = X2
      ESI(I) = SI
   50 SI = SI + SINC
C
      SI = 1
      I = 1
        EI = 5
C
60      CONTINUE
C           PROCESS REMAINING SEGMENT END POINTS
      DO 120 E=EI,EIN,4
      Y = EDGE(E)
      IF(Y.EQ.Y0) GOTO 90
C           ADVANCE SBUF ONE ROW
      SI = SI + SINC
      I = I + 1
      IF(SI.GT.MAXSB) SI=1
```

```
      IF(I.GT.B2) I=1
      IF(YBAR.LT.0) GOTO 82
C           RELEASE SEGMENTS ON LINE Y0 - 0
      SEND = ESI(I)
      DO 80 SIP=SI,SEND,2
      SEG(S) = YBAR
      SEG(S+1) = SBUF(SIP)
      SEG(S+2) = SBUF(SIP+1)
   80 S = S + 3
C
   82 Y0 = Y0 + 1
      YBAR = YBAR + 1
      SBUF(SI) = EDGE(E+1)
      SBUF(SI+1) = EDGE(E+3)
      ESI(I) = SI
C
   90 SIP = 1
      X10= EDGE(E+1)
      X20= EDGE(E+3)
C
      DO 100 II=1,B2
      SIQ = SIP
      SEND = ESI(II)
      X1 = X10
      X2 = X20
C
   93 XP1 = SBUF(SIQ)
      IF(X2.LT.XP1-1) GOTO 95
      XP2 = SBUF(SIQ+1)
      IF(X1.GT.XP2+1) GOTO 95
C          SEGMENT (X1,X2) IS CONNECTED TO A PREVIOUS SEGMENT
      IF(SIQ.EQ.SEND) GOTO 94
      X1 = MIN0(X1,XP1)
      X2 = MAX0(X2,XP2)
      SBUF(SIQ) = SBUF(SEND)
      SBUF(SIQ+1) = SBUF(SEND+1)
      SEND = SEND - 2
      GOTO 93
C
   94 SBUF(SEND) = MIN0(X1,XP1)
      SBUF(SEND+1) = MAX0(X2,XP2)
      GOTO 98
C
   95 SIQ = SIQ + 2
      IF(SIQ.LE.SEND) GOTO 93
      SBUF(SIQ) = X1
      SBUF(SIQ+1) = X2
C
   98 ESI(II) = SIQ
  100 SIP = SIP + SINC
C
  120 CONTINUE
C
       EI = 1
130    NEND = NEND - EIN
C
C           RELEASE REMAINING SEGMENTS
      DO 150 II=1,B2
      IF(YBAR.GT.NL) GOTO 180
      SI = SI + SINC
      I = I + 1
      IF(SI.GT.MAXSB) SI=1
      IF(I.GT.B2) I=1
      SEND = ESI(I)
      DO 140 SIP=SI,SEND,2
      SEG(S) = YBAR
      SEG(S+1) = SBUF(SIP)
      SEG(S+2) = SBUF(SIP+1)
  140 S = S + 3
C
  150 YBAR = YBAR + 1
C
180    SDIR(DI+1) = S - 1
C
```

```
C
      DI = DI + 6
      IF(DI.LT.MAXDI) GOTO 200
      CALL WRITE(SEGB,DREC,DIR)
      CALL WRITE(SEGB,DREC+1,SDIR)
      DREC = DREC + 2
      DI = 1
200   CONTINUE
C
C
      IF(DI.EQ.1) GOTO 205
      CALL WRITE(SEGB,DREC,DIR)
      CALL WRITE(SEGB,DREC+1,SDIR)
C           WRITE OUT SEGMENT
205   DO 210 I=1,S,512
      CALL WRITE(SEGB,OREC,SEG(I))
210   OREC = OREC + 1
      CALL CLOSE(SEGB)
      CALL CLOSE(EBUF)
      END


      SUBROUTINE CHROME(DUNIT,FILPEX)
      BYTE FILPEX(9)
      IMPLICIT INTEGER(A-Z)
      COMMON/C1/SLO,SSO,NLO,NSO,NOB,B
      COMMON/C1/DIR(512),CMVB(1952),C(512),PBUF(1300)
C THE FIRST 28 WORDS OF PBUF ARE THE MVB, FOLLOWED BY 1024 WORDS OF
C BUFFER STORAGE, FOLLOWED BY 256 WORDS OF PICTURE STORAGE
      COMMON/C1/SEGB(56),CBUF(5600),CDIR(510),LBW(100)
      COMMON/C1/OREC,NFSI
      BYTE SEGB,PB(2616)
      EQUIVALENCE (PB,PBUF)
      INTEGER PAR(5)
      DATA SECSIZ/64/,SSM1/63/
      DATA MAXDI/510/,MAXBUF/9600/,IDREC/2/,LPBUF/1052/,DREC/2/
C LPBUF IS THE LENGTH OF PBUF MINUS 256 WORDS OF PICTURE STORAGE
C
      CALL SSWTCH(1,ISW1)
      IF(ISW1.EQ.1) CALL TYPE(' CHROME')
      CALL SSWTCH(4,ISW4)
      IF(ISW4.NE.1) GOTO 3
      CALL QPRINT(' CHROME')
      CALL TIMER
      MAXBUF=7320
3     CONTINUE
      CALL AFILE(PBUF,DUNIT,FILPEX,2,2)
      CALL OPEN(PBUF,LPBUF-28,1,0,0,'SCN')
      CALL GLABEL(PBUF,PAR,IP)
      NW=(PAR(2)+1)/2
      CALL AFILE(SEGB,5,'PIC       ',5,5)
      CALL OPEN(SEGB,1024,0,0,'MV5')
      CALL GLABEL(SEGB,PAR,IND)
      CALL ZIA(CMVB,28)
      CALL AFILE(CMVB,1,'PIC       ',5,5)
      CALL OPEN(CMVB,1024,1,1,'MV2')
      CALL MVL(' CHROME FILE',PB(IP+180),12)
      CALL PLABEL(CMVB,PAR,PB(IP+1))
      CALL READ(SEGB,1,IND,SLO)
      CALL PUT(CMVB,1,IC)
      CALL MVW(SLO,CMVB(IC/2+1),512)
      NREC = (NOB+84)/85
      IREC = 2*NREC + 2
      OREC = NREC + 3
      CALL READ(SEGB,IDREC,IND,DIR)
      CALL PUT(CMVB,DREC,IC)
      CALL MVW(DIR,CMVB(IC/2+1),512)
      CALL READ(SEGB,IDREC+1,IND,DIR)
      IDREC = IDREC + 2
      DREC = DREC + 1
C           FORMAT CBUF
      DEND = NOB+6
      SEND = DIR(DEND-4)
      DISP = MAXBUF-SEND
C
      J = DISP + 1
```

```
C                READ IN SEGMENT FILE
        DO 5 I=1,SEND,512
        CALL READ(SEGB,IREC,IND,CBUF(J))
        J = J + 512
5       IREC = IREC + 1
C
        DO 6 DI=1,DEND,6
        DIR(DI) = DIR(DI) + DISP
6       DIR(DI+1) = DIR(DI+1) + DISP
C
        TNS = (DISP-1)/SECSIZ
        N = TNS*SECSIZ
C
        DO 10 I=1,N,SECSIZ
10      CBUF(I) = I+SECSIZ
C
        LFSI = N - SSM1
        CBUF(LFSI) = 0
C  THE SEGMENT DIRECTORY CONTAINS THE FOLLOWING INFORMATION FOR EACH OBJ
C           DIR(DI) = CSI = CURRENT SEGMENT INDEX
C           DIR(DI+1) = ESI = ENDING SEGMENT INDEX
C           DIR(DI+2) = YMIN
C           DIR(DI+3) = XMIN
C           DIR(DI+4) = YMAX
C           DIR(DI+5) = XMAX
C
C  THE CHROMOSOME DIRECTORY CONTAINS THE FOLLOWING INFORMATION FOR EACH
C           CDIR(DI) = BSI = BEGINNING SEGMENT INDEX
C           CDIR(DI+1) = NSEC = TOTAL NUMBER OF SECTIONS USED UP BY OBJEC
C           CDIR(DI+2) = FSI = INDEX OFFIST SECTION USED BY OBJECT
C           CDIR(DI+3) = LSI = INDEX OF LAST SECTION USED BY OBJECT
C           CDIR(DI+4) = FHW = FIRST HALFWORD OF SECTION USED BY OBJECT
C           CDIR(DI+5) = LHW = LAST HALFWORD OF SECTION USED BY OBJECT
C
C           NFSI = NEXT FREE SECTION INDEX
C           LFSI = LAST FREE SECTION INDEX
        NFSI = 1
        DI = 1
C
   50 DBEG = DI
        IF(ISW4.EQ.1) CALL TIMER
C           INCREASE NUMBER OF SECTIONS IF POSSIBLE
        CSI = DIR(DI)
        BSI = CDIR(DI)
        IF(BSI.EQ.0) BSI = CSI
   51 NSI = LFSI + SECSIZ
        IF(NSI.GT.BSI-SECSIZ) GOTO 52
        CBUF(LFSI) = NSI
        LFSI = NSI
        GOTO 51
C
   52   CBUF(LFSI) = 0
        Y0 = CBUF(CSI)
          REC = 2*Y0 - 1
          CALL GET(PBUF,REC,IND)
          CALL MVW(PBUF(IND/2+1),PBUF(LPBUF+1),NW)
          CALL GET(PBUF,0,IND)
          IP=IND/2
C
C           PROCESS OBJECTS 1 TO NOB
C         IF(ISW4.EQ.1) CALL TIMER
        DO 100 DI=DBEG,DEND,6
        CSI = DIR(DI)
        IF(CSI.EQ.0) GOTO 100
        Y = CBUF(CSI)
        IF(Y.GT.Y0) GOTO 110
        ESI = DIR(DI+1)
        LSI = CDIR(DI+3)
        LHW = CDIR(DI+5)
        NSEC = 0
        IF(LSI.NE.0) GOTO 58
C           FIRST SEGMENT OF OBJECT.  ASSIGN A SECTION
          IF(NFSI.EQ.0) CALL TYPE(' UNBUF1')
        IF(NFSI.EQ.0) CALL UNBUF(DBEG,DEND,DI)
```

```
      CDIR(DI) = CSI
      CDIR(DI+1) = 1
      CDIR(DI+2) = NFSI
      CDIR(DI+4) = 1
        CDIR(DI+5)=1
      LSI = NFSI
      NFSI = CBUF(NFSI)
      LHW = 1
C
C           LOOP THROUGH EACH SEGMENT OF CURRENT OBJECT
   58 DO 80 SI=CSI,ESI,3
      Y = CBUF(SI)
      IF(Y.GT.Y0) GOTO 82
      X1 = CBUF(SI+1) + LPBUF
      X2 = CBUF(SI+2) + LPBUF
C
      DO 70 L=1,2
C
      DO 62 X=X1,X2
      IF(LHW.LT.SECSIZ) GOTO 60
C           ADD ON A NEW SECTION
        IF(NFSI.EQ.0) CALL TYPE('-WMBUF2')
      IF(NFSI.EQ.0) CALL WMBUF(DBEG,DEND,DI)
      NSEC = NSEC + 1
      CBUF(LSI) = NFSI
      LSI = NFSI
      NFSI = CBUF(NFSI)
      LHW = 1
C
   60 CBUF(LSI+LHW) = PBUF(X)
   62 LHW = LHW + 1
C
        X1=CBUF(SI+1)+IP
   70   X2=CBUF(SI+2)+IP
C
   80 CONTINUE
C
      CDIR(DI+3) = LSI
      CDIR(DI+5) = LHW
C           END OF OBJECT -- WRITE OUT TO DISK
C       IF(ISW4.EQ.1) CALL TIMER
   81 CALL WBUF(DI)
      CSI = DIR(DI)
      IF(CSI.NE.9) GOTO 81
C       IF(ISW4.EQ.1) CALL TIMER
      GOTO 100
C
C           REMAINING PORTION OF OBJECT LIES BELOW CURRENT LINE
C           UPDATE DIRECTORIES AND CONTINUE
   82 CDIR(DI+1) = CDIR(DI+1) + NSEC
      CDIR(DI+3) = LSI
      CDIR(DI+5) = LHW
      DIR(DI) = SI
  100 CONTINUE
C
C           NO MORE OBJECTS ON THIS LINE.  UPDATE AND CONTINUE.
  110   CONTINUE
C       IF(ISW4.EQ.1) CALL TIMER
      DO 120 DI=DBEG,DEND,6
      CSI = DIR(DI)
      IF(CSI.NE.0) GOTO 50
  120 CONTINUE
C
        IF(ISW4.EQ.1) CALL TIMER
        CALL PUT(CNVB,DREC,IC)
        CALL MVW(LBW,CNVB(IC/2+1),102)
        CALL CLOSE(CNVB)
        CALL CLOSE(PBUF)
        CALL CLOSE(SEGB)
        IF(ISW4.EQ.1) CALL TIMER
      END
```

```
      SUBROUTINE ROB
     IMPLICIT INTEGER(A-Z)
      COMMON/C1/CMVB(56),C(512)
      COMMON/C1/SMVB(56),EDGE(1024),LBW(80),BUF,STBL
      COMMON/C1/SLO,SSO,NLO,NSO,NOB,B,DPER
      COMMON/C1/N,PERIM,YMIN,XMIN,YMAX,XMAX
      COMMON/C1/SDIR(660),TTAB(60),AREA(60),IOD(60)
      COMMON/C1/NK,LIP(60),SIP(60),PERM(60),CIRCA(60)
      LOGICAL*1 BUF(10900)
      BYTE CMVB,SMVB,STBL(129),MSG7(20),MSG8(25),TMSG(128)
      INTEGER DIR(510),PAR(100),HIS(64),OTTAB(60)
      EQUIVALENCE (DIR,SDIR(145)),(HIS,EDGE)
      DATA MAXBUF/10000/,RECSIZ/1024/,NOBPH/6/
      DATA NC/0/,IODTOT/0/,NPTOT/0/,MAXNOB/60/,TOBN/0/,MAXNP/100/
      DATA OREC/2/,DREC/2/,RFLAG/1/,OTTAB/60*0/
C
C    THE INPUT CHROMOSOME DIRECTORY CONTAINS THE FOLLOWING FOR EACH OBJ
C          DIR(DI) = BACKGROUND
C          DIR(DI+1) = THRESHOLD
C          DIR(DI+2) = CML (MINIMUM LINE)
C          DIR(DI+3) = CMS (MINIMUM SAMPLE)
C          DIR(DI+4) = CMXL (MAXIMUM LINE)
C          DIR(DI+5) = CMXS  (MAXIMUM SAMPLE)
C    THE OUTPUT CHROMOSOME DIRECTORY CONTAINS THE FOLLOWING FOR EACH OBJ
C          SDIR(CDI)= FBW (FIRST RECORD BLOCK WRITTEN TO DISK)
C          SDIR(CDI+1)= ML (MINIMUM LINE)
C          SDIR(CDI+2)= MS (MINIMUM SAMPLE)
C          SDIR(CDI+3)= LBW (LAST RECORD BLOCK WRITTEN TO DISK)
C    THE INPUT CHROMOSOMES ARE IN THE FOLLOWING FORMAT
C          C(1) = PREVIOUS BLOCK WRITTEN
C          C(2) = NSEG (NUMBER OF SEGMENTS IN THIS RECORD)
C          C(CI) = Y (LINE COORDINATE=0 - 255)
C          C(CI+1) = X (STARTING SAMPLE COORDINATE=0 - 255)
C          C(CI+2) = N (NUMBER OF SAMPLES IN SEGMENT)
C      NOTE THAT TWO CONSECUTIVE LINES OF SEGMENT GREY VALUES ARE PRESENT
C      ALSO, THE DIMENSIONS ARE THOSE OF THE HALF-PICTURE AND MUST BE
C      DOUBLED.
C    THE OUTPUT CHROMOSOMES ARE IN THE FOLLOWING FORMAT
C          C(1) = NSEG (NUMBER OF SEGMENTS IN THIS RECORD)
C          C(CI) = Y (LINE COORDINATE=1 - 512)
C          C(CI+1) = X (STARTING SAMPLE COORDINATE=1 - 512)
C          C(CI+2) = N (NUMBER OF SAMPLES IN SEGMENT)
C
      CALL SSWTCH(1,ISW1)
      IF(ISW1.EQ.1) CALL TYPE(' ROB')
      CALL SSWTCH(4,ISW4)
      IF(ISW4.EQ.1) CALL QPRINT(' ROB')
      CALL RPARAM(NP,PAR,MAXNP)
      IP=1
20    IF(IP.GT.NP) GOTO 35
      IF(PAR(IP).EQ.'TO') GOTO 30
      IF(PAR(IP).NE.'OT') GOTO 35
      OTTAB(PAR(IP+2))=PAR(IP+3)
      IP=IP+4
      GOTO 20
30    TOBN=PAR(IP+2)
      IP=IP+3
      GOTO 20
35    CONTINUE
     RECSZ2 = RECSIZ/2
C          LBW(80) = LAST BLOCK WRITTEN FOR CURRENT CHROMOSOME
C          DI = DIRECTORY INDEX
C          NC = NUMBER OF CHROMOSOMES
C
      CALL AFILE(CMVB,1,'PIC       ',5,5)
      CALL OPEN(CMVB,1024,0,3,'MV2')
      CALL AFILE(SMVB,5,'UCR       ',*13,*13)
      CALL OPEN(SMVB,1024,0,1,'UCR')
      CALL GLABEL(CMVB,PAR,IND)
      CALL MVL(' ROB FILE   ',CMVB(IND+139),12)
      CALL PLABEL(SMVB,PAR,CMVB(IND+1))
      CALL SSWTCH(0,ISW0)
      IF(ISW0.NE.1) GOTO 37
      CALL QPRINT('1')
      CALL QPRINT(CMVB(IND+73),70)
```

```
      CALL QPRINT(CMVB(IND+145),30)
      CALL QPRINT(CMVB(IND+217),70)
      CALL QPRINT('0OBJ   PER      B          D MAX    LINE    SAMP
     1   SL    SS    NL    NS          T1     T2     FPON     AREA     IOD/8   AVG
     2   OBJ')
37    CALL ITLA(32,TMSG,128)
      CALL PUT(SMVB,DREC,IND)
      CALL READ(CMVB,1,IND,SLO)
      CALL READ(CMVB,DREC,IND,DIR)
      DREC = DREC + 1
      CALL READ(CMVB,DREC,IND,LBW)
      BPER = 100 - DPER
      B = 2*B
      B1 = B + 1
      B2 = B + 2
      B3 = 2*B + 1
      DI = 1
      CDI = 2
C         LOOP THROUGH EACH OBJECT
      DO 500 OBN=1,NOB
      REC = LBW(OBN)
      CML = DIR(DI+2)*2 - 1
      CMS = DIR(DI+3)*2 - 1
      CMXL = DIR(DI+4)*2
      CMXS = DIR(DI+5)*2
      CNL = CMXL - CML + 3
      CNS = CMXS - CMS + 2
      CMLM1 = CML - 1
      CMSM1 = CMS - 1
      IF(CNL*CNS.LT.MAXBUF) GOTO 50
45      CALL SSWTCH(1,ISW1)
        IF(ISW1.NE.1) GOTO 500
        CALL MVL(' OBJECT ** TOO LARGE',MSG7,20)
      CALL OUTCON(OBN,MSG7(10),2)
        CALL TYPE(MSG7,20)
      GOTO 500
C
C           READ IN CURRENT CHROMOSOME
50      CALL ZIA(BUF,MAXBUF/2)
        CALL ZIA(HIS,64)
C
51      CALL READ(CMVB,REC,IND,C)
      NSEG = C(2)
      CI = 3
C
      DO 60 NN=1,NSEG
      BI = 2*(C(CI)*CNS+C(CI+1)) + CNS + 1
      N = C(CI+2)
        N2 = 2*N
        IF(BI.LT.1) GOTO 60
C IGNORE POSSIBLE BUFG FROM CHROME OUTPUT ********
        IF(BI.GT.MAXBUF) GOTO 45
      IF(N.LT.1.OR.N.GT.100) GOTO 45
      CALL NHIS(C(CI+3),BUF(BI),HIS,N2)
      CALL NHIS(C(CI+N+3),BUF(BI+CNS),HIS,N2)
   60 CI = CI + N2 + 3
C
      REC = C(1)
      IF(REC.NE.0) GOTO 51
CCCCCCCC
        IF(OBN.NE.TOBN) GOTO 63
        BI = 1
        DO 62 I=1,CNL
        CALL PRT(1,BUF(BI),CNS)
62      BI = BI + CNS
63      CONTINUE
CCCCCCCC
C
      BACK = DIR(DI)/2
      ITHRES = DIR(DI+1)/2
C           RETHRESHOLD OBJECT
        HIS(1) = 0
        DATA = ITHRES
        THRESH = ITHRES
```

```
      IF(RFLAG.EQ.0) GOTO 72
      HIS(64) = 0
      MAX = 0
C
      DO 65 I=ITHRES,63
      F = HIS(I-1) + HIS(I) + HIS(I+1)
      IF(F.LE.MAX) GOTO 65
      MAX = F
      DATA = I
65    CONTINUE
      THRESH =(BPER*BACK + BPER*DATA)/100
      IF(OTTAB(OBN).NE.0) THRESH=OTTAB(OBN)/2
72    CALL STRECH(HIS,STBL,THRESH,DMAX)
C
C       BI = BUFFER INDEX        EI = EDGE INDEX
C       DI = DIRECTORY INDEX     CDI = CHROMOSONE DIRECTORY INDEX
      EBI = CNS
      EI = 1
      CNL2 = CNL - 2
      CNS1 = CNS - 1
      THRESH = THRESH*2
      NLB = CNL2 - B
      NSB= CNS1-B
      BCNS = B*CNS
C
      DO 300 L=1,CNL2
      BI = EBI + 1
      EBI = EBI + CNS
C
  210 IF(ISEG(BI,BUF,THRESH,EBI).EQ.0) GOTO 300
      SDIR(CDI) = OREC+ 1
      EDGE(1) = L
      S = CNS - (EBI - BI)
      EDGE(2) = S
      CALL SOT(N,EDGE,BUF(BI),THRESH,CNS)
      IF(N.EQ.0) GOTO 210
      IF(OBN.EQ.TOBN) CALL ILIST(N,YMIN,XMIN,YMAX,XMAX)
      IF(OBN.EQ.TOBN) CALL PDUMP(EDGE,EDGE(2*N),1)
      IF(N.GE.255) GOTO 213
      CALL SORTIN(EDGE,N,SIND)
      IF(SIND.EQ.0) GOTO 215
213   IF(N.LE.512) GOTO 214
      CALL TYPE(' EDGE OVERFLOW, THRESHOLD RAISED')
      CALL TYPE(' ')
      THRESH = THRESH + 4
      GOTO 210
214   IF(ISW1.EQ.1) CALL TYPE('   SORT')
      IF(ISW4.EQ.1) CALL STIMER
      CALL SORT(EDGE,N)
      IF(ISW4.EQ.1) CALL TIMER
215   CONTINUE
      IF(OBN.EQ.TOBN) CALL PDUMP(EDGE,EDGE(2*N),1)
      IF(OBN.EQ.TOBN) CALL ILIST(L,S,CNL,CNS,OBN)
C         MAKE SURE THAT OBJECT CONTAINS AN INTERNAL POINT
      INTPNT = 0
      N2 = 2*N
      DO 235 E=1,N2,4
      Y = EDGE(E)
      IF(Y.LT.BI.OR.Y.GT.NLB) GOTO 235
      X1 = MAX0(EDGE(E+1),BI)
      X2 = MIN0(EDGE(E+3),NSB)
      IF(X1.GT.X2) GOTO 235
      BB = Y*CNS + X1
      I = BB - B
C
      DO 220 LEFT=I,BB
      IF(IV(BUF(LEFT)).NE.0) GOTO 221
220   CONTINUE
C
221   RIGHT = BB + X2-X1  + B
C
      DO 222 I=1,B1
      IF(IV(BUF(RIGHT)).NE.0) GOTO 223
222   RIGHT = RIGHT - 1
C
```

```
223     LEFT = LEFT + 8
        RIGHT = RIGHT - 8
        IF(TOBN.EQ.OBN) CALL ILIST(X1,X2,LEFT,RIGHT,Y)
        IF(LEFT.GT.RIGHT) GOTO 235
C
        DO 230 I=LEFT,RIGHT
        TP = I - BCNS - 1
        BP = I + BCNS + 1
        DO 225 LL=1,BCNS,CNS
        IF(TOBN.EQ.OBN) CALL ILIST(TP,BP,LL,IV(BUF(TP+LL)),IV(BUF(BP-LL)))
        IF(IV(BUF(TP+LL)).EQ.0.OR.IV(BUF(BP-LL)).EQ.0)GOTO 230
225     CONTINUE
C               THIS IS AN INTERNAL POINT
        INTPNT = 1
        GOTO 236
C
230     CONTINUE
235     CONTINUE
C
C          REMOVE OBJECT FROM BUF
236     NSEG = 0
      NP = 0
      IODN = 0
      ECI = 1
C
      DO 250 E=1,N2,4
      Y = EDGE(E)
      X1 = EDGE(E+1)
      X2 = EDGE(E+3)
      NS = X2 - X1 + 1
        IF(NS.GT.0) GOTO 238
        CALL TYPE(' ROB - NS LE 0')
        CALL TYPE('0')
        CALL ILIST(E,N2,X1,X2,NS)
        PAUSE
        GOTO 250
238     CONTINUE
      NS2 = (NS+1)/2
      BCI = ECI + 1
      ECI = ECI + NS2 + 3
      IF(ECI.LE.RECSZ2) GOTO 240
C
C            WRITE OUT CHROMOSOME LINE
      C(1) = NSEG
      OREC = OREC + 1
        CALL WRITE(SMVB,OREC,C)
      NSEG = 0
      BCI = 2
      ECI = NS2 + 4
C
  240 C(BCI) = CMLM1 + Y
      C(BCI+1) = CMSM1 + X1
      C(BCI+2) = NS
        CALL REMOVE(BUF(Y*CNS+X1),C(BCI+3),STBL,NS,IODN,THRESH)
      NP = NP + NS
  250 NSEG = NSEG + 1
C
        IF(NP.GE.25.AND.INTPNT.NE.0) GOTO 260
        CALL SSWTCH(4,ISW4)
        IF(ISW4.NE.1) GOTO 210
        CALL QPRINT(' OBJECT REJECTED')
        CALL ILIST(OBN,N,NP,YMIN,XMIN)
        CALL ILIST(YMAX-YMIN,XMAX-XMIN,L,S,NC)
        GOTO 210
C          WRITE OUT LAST LINE
260     OREC = OREC + 1
      C(1) = NSEG
        CALL WRITE(SMVB,OREC,C)
C
      NC = NC + 1
      NL = YMAX - YMIN + 1
      NS = XMAX - XMIN + 1
      IODN = IODN - BACK*NP/4
      FTAB(NC) = THRESH
      LIP(NC) = CMLM1 + L
```

```
      SIP(NC) = CMSM1 + S
      IOD(NC) = IODN
      AREA(NC) = NP
        PERM(NC) = PERIM
        CALL SSWTCH(0,ISW0)
        IF(ISW0.NE.1) GOTO 280
C PRINT IF SW0 IS UP
      CALL OUTCON(NC,TMSG(4),2)
      CALL OUTCON(PERM(NC),TMSG(10),3)
      CALL OUTCON(BACK*2,TMSG(17),3)
      CALL OUTCON(DATA*2,TMSG(27),3)
        CALL OUTCON(DMAX*2,TMSG(31),3)
      CALL OUTCON(CML,TMSG(39),4)
      CALL OUTCON(CMS,TMSG(47),4)
      CALL OUTCON(CMLM1+L,TMSG(55),5)
      CALL OUTCON(CMSM1+S,TMSG(60),5)
      CALL OUTCON(NL,TMSG(65),5)
      CALL OUTCON(NS,TMSG(70),5)
      CALL OUTCON(ITHRES*2,TMSG(80),3)
      CALL OUTCON(THRESH,TMSG(86),3)
      CALL OUTCON(OBH,TMSG(94),2)
      CALL OUTCON(NP,TMSG(102),8)
      CALL OUTCON(IODN,TMSG(111),9)
        CALL OUTCON(IODN/(NP/8),TMSG(116),3)
      CALL OUTCON(NC,TMSG(122),2)
      CALL QPRINT(TMSG,128)
C           ENTER OBJECT IN CHROMOSOME DIRECTORY
280       SDIR(CDI+1) = CML + YMIN - 1
      SDIR(CDI+2) = CMS + XMIN - 1
      SDIR(CDI+3) = OREC
      CDI = CDI + 4
      IF(NC.EQ.MAXNOB) GOTO 519
      GOTO 210
C
  300 CONTINUE
  500 DI = DI + 6
C
510     CONTINUE
      SDIR(1) = CDI/4
        NK=SDIR(1)
        TEMP=PERM(1)
        PERM(1)=64
C STORE NOB PARAMETER TEMPORARILY IN PERM(1)
        CALL QPARAM(122,NK,NOBPH)
        PERM(1)=TEMP
C WRITE NOB PARAMETERS
        CALL MVW(ITAB,SDIR(241),60)
        CALL WRITE(SMVB,1,SDIR)
        CALL WRITE(SMVB,2,LIP)
        IF(ISW0.EQ.1) CALL QPRINT('1')
        CALL CLOSE(SMVB)
        CALL CLOSE(CMVB)
        END


C*******
C*      *
C* NOB  *    CALMS VERSION
C*      *
C*******
C
C NOB NUMBERS THE RAW SPREAD WITH THE OBJECT NUMBERSGENERATED
C BY FOB
C
        SUBROUTINE NOB(DUNIT,FILPEX)
        IMPLICIT INTEGER(A-Z)
        COMMON/C1/ NK,LT,ST,FI
        LOGICAL ORDER
        BYTE FILPEX(9)
C I/O BUFFERS
        BYTE IBUF2(12344),OBUF(12344)
C RANDOM AREAS
        INTEGER SPAR(10)
        BYTE CHAR(2)
```

```
C SAMPLE AND LINE TABLES FOR OBJECT NUMBERS
      INTEGER ST(60),LT(60),TEMP(60)
      DATA Y/0/,X/0/,REPL/1/,MASKPH/13/
C
C INITIALIZE DATA SETS
C
      CALL SSWTCH(1,ISW1)
      IF(ISW1.EQ.1) CALL TYPE(' NOB')
C
C READ PARAMETERS
C
      CALL RPARAM(NP,NK,122)
      IF(FI.EQ.0) CALL APHASE(MASKPH)
      IF(FI.NE.0) CALL DCLEAR
C CLEAR THE GRAY SCALE UNLESS FINISHING UP A COUNT
      CALL AFILE(IBUF2,DUNIT,FILPEX,2,2)
      CALL AFILE(OBUF,1,'PIC      ',*5,*5)
      CALL OPEN(IBUF2,6144,1,0,'SCN')
      CALL OPEN(OBUF,6144,1,1,'NOB')
      CALL GLABEL(IBUF2,SPAR,I2)
      NLI=SPAR(1)
      NSI=SPAR(2)
      NW=NSI/2
      N1=1
      CALL PLABEL(OBUF,SPAR,IBUF2(I2+1))
C
C SEE IF LT IS IN ORDER
      ORDER=.TRUE.
      IF(NK.LT.2) GOTO 45
      DO 40 N=2,NK
      IF(LT(N).LT.LT(N-1)) GOTO 42
40    CONTINUE
      GOTO 45
42    ORDER=.FALSE.
45    CONTINUE
C
C RUN THROUGH EACH LINE OF THE PICTURE
C
      DO 500 L=1,NLI
      CALL GET(IBUF2,L,I2)
      CALL PUT(OBUF,L,0)
      CALL MVW(IBUF2(I2+1),OBUF(O+1),NW)
C
C GENERATE NUMBER FOR EACH OBJECT AT APPROPRIATE TIME
C
      IF(NK.EQ.0.OR.N1.GT.NK) GOTO 210
      DO 200 N=N1,NK
      LD=L-LT(N)
      IF(LD.GT.4) GOTO 200
      IF(LD.GE.-4) GOTO 48
      IF(ORDER) GOTO 210
      GOTO 200
48    CONTINUE
      SD=ST(N)-13
      NCHAR=2
      IF(N.GE.10) GO TO 50
      NCHAR=1
      SD=SD+6
50    IF(SD.LT.1) SD=1
      IF(LD.EQ.-4) GOTO 75
      IF(LD.EQ.4) GOTO 70
      CALL OUTCON(N,CHAR(2),2)
      CALL TEXT(CHAR(3-NCHAR),NCHAR,LD+3,OBUF(O+SD),1)
      CALL ITL(0,OBUF(O+SD+6*NCHAR))
      GO TO 200
70    IF(ORDER) N1=N1+1
75    CALL ITLA(0,OBUF(O+SD),6*NCHAR+1)
200   CONTINUE
210   IF(FI.EQ.0) GOTO 500
C NO DISPLAY IF FINISHING UP A COUNT
      CALL DLINE(OBUF(O+1),Y,X,NSI,REPL,0)
      Y=Y+REPL+1
500   CONTINUE
C
C CLOSE DATA SETS
```

```
C
      CALL CLOSE(IBUF2)
      CALL CLOSE(OBUF)
      CALL EXIT
      END


C     INT1 - INTERACTION 1 TO CHECK NOB OUTPUT AND CORRECT FOB ERRORS
      SUBROUTINE INT1(DUNIT,FILPEX)
      IMPLICIT INTEGER (A-Z)
      COMMON/C1/ NK,LTAB,STAB,FI
      INTEGER PAR(10),SPAR(5),SST(513),NST(513),TTAB(133),MPAR(5)
      INTEGER XTAB(60),YTAB(60),LTAB(60),STAB(60),TEMP(60),RPAR(100)
      BYTE A(12344),BLACK(512),FILPEX(9),BPAR(20),KEY(20),LIGHT(512)
      BYTE MB(19),MT(21),GMSG(128),MK(8),WHITE(8),CHAR(2)
      BYTE BELL(3)
      EQUIVALENCE (PAR,BPAR),(NC,TTAB(2)),(LPS,TTAB(3)),(SPS,TTAB(4))
      EQUIVALENCE (NL,SPAR(1)),(NS,SPAR(2))
      DATA BELL/'+',7,0/
      DATA NTIME/1000/
      DATA MASKPH/13/,NOBPH/6/,ERASE/'105/,KOUNT/'113/,ROBPH/5/
      DATA NKEY/20/,KEY/'H','C','J','B','T','A','F','S','I','N'
     1,'U','D','L','R','K','M','X','2','Q','O'/
      NFLAG=1
C ALWAYS SET NFLAG TO 1
C FLAG TO CALL NOB FOR A FINISH COUNT
      CALL ITLA(32,LIGHT,512)
      CALL ZIA(WHITE,4)
      CALL MVL(' DN=*** BACK=***  ',MB,18)
      CALL MVL(' DN=*** THRESH=***  ',MT,20)
      CALL MVL(' NC=** ',MK,7)
      MB(19)=0
      MT(21)=0
      MK(8)=0
      RERUN=0
      CALL TYPE('0CHECK SPREAD',0)
      NK=0
      CALL RPARAM(NRP,RPAR,100,ROBPH)
      CALL RPARAM(NP,NK,122,NOBPH)
      IF(NP.EQ.0) FI=64
      CALL DCOUNT(NK,FI)
C DISPLAY THE COUNT
20    CALL ITLA(32,GMSG,128)
      CALL RCA
C READ CURSOR ADJUSTMENTS
      CALL AFILE(A,DUNIT,FILPEX,2,2)
C OPEN SCAN DATA SET AND READ TTAB
      CALL OPEN(A,6144,1,2,'SCN')
      CALL GLABEL(A,SPAR,IA)
      CALL MVL(A(IA+73),GMSG,64)
C SAVE LABEL FOR PATIENT REPORT
      CALL GET(A,SPAR(1)+1,IA)
      CALL MVU(A(IA+1),TTAB,133)
25    CONTINUE
      CALL PARAM(NP,PAR,10)
30    IF(NP.EQ.0) GOTO 1000
35    IF(PAR(1).EQ.'RS') GOTO 80
      IF(PAR(1).EQ.'SM') GOTO 85
      DO 50 K=1,NKEY
      IF(IV(BPAR(1)).NE.IV(KEY(K))) GOTO 50
      GOTO (90,100,200,300,400,500,600,700,800,850,900,910,920,930,940
     1,1100,1200,1300,1350,1400),K
50    CONTINUE
60    CALL TYPE(' PARAMETER ERROR')
65    CALL TYPE('0')
      GOTO 25
80    CONTINUE
C RS - RESCAN
C
      CALL APHASE(1)
      CALL CLOSE(A)
      CALL EXIT
```

```
85      CONTINUE
C
C SM - SKIP MOB AND CLASFY
C
        CALL APHASE(10)
        CALL CLOSE(A)
        CALL EXIT
90      CALL TYPE(' TYPE ONE OF THE FOLLOWING KEYWORDS TO SELECT AN OPTION')
        CALL TYPE(' Q - QUICK COUNT')
        CALL TYPE(' C - CUT APART A TOUCH (POSITION CURSOR FIRST)')
        CALL TYPE(' J - JOIN TWO PIECES TOGETHER (USE CURSOR)')
        CALL TYPE(' T - CHANGE THRESHOLD (USE CURSOR)')
        CALL TYPE(' B - CHANGE BACKGROUND (USE CURSOR)')
        CALL TYPE(' S - SET UP THE CURSOR TO CORRECT FOR DRIFT')
        CALL TYPE(' A - ABORT THIS SPREAD')
        CALL TYPE(' RS - RESCAN')
        CALL TYPE(' F - FINISH THIS SPREAD (NO KARYOTYPE)')
        CALL TYPE(' F,NN - FINISH THIS SPREAD; IT HAS NN CHROMOSOMES')
        CALL TYPE(' I - DISPLAY THE INITIAL (UN-NUMBERED) SPREAD')
        CALL TYPE(' N - DISPLAY THE NUMBERED SPREAD')
        CALL TYPE(' E - ERASE THE LAST CUT OR JOIN REQUEST')
        CALL TYPE(' U,D,L,OR R - MOVE THE CURSOR UP,DOWN,LEFT, OR RIGHT')
        CALL TYPE(' K - INTERACTIVE COUNT WITH CURSOR AND BELL')
        CALL TYPE(' M - ADD A MISSING NUMBER (ONLY FOR COUNTS)')
        CALL TYPE(' X - REMOVE AN EXTRA NUMBER (ONLY FOR COUNTS')
        CALL TYPE(' Z - ZERO THE CHROMOSOME COUNT')
        CALL TYPE(' SM - SKIP MOB (USE OLD RCR)')
        CALL TYPE(' OT N,T - SET THRESH FOR OBJECT N TO T')
        CALL TYPE(' IF SPREAD IS OK, TYPE CARRIAGE RETURN')
        CALL TYPE('0')
        GOTO 25
C
C       C - CUT APART A TOUCH
C
100     CALL CURSOR(Y1,X1,SL,SS)
        CALL TYPE('+MOVE CURSOR TO END OF CUT ',0)
        DO 105 J=1,2
        DO 105 I=1,3
105     CALL DLINE(WHITE,Y1-2+I,X1-1,3,0,0)
C MARK THE FIRST ENDPOINT
110     CALL PARAM(NP,PAR,10)
        IF(NP.EQ.0) GOTO 120
        P=PAR(1)
        IF(P.EQ.'U '.OR.P.EQ.'D '.OR.P.EQ.'L '.OR.P.EQ.'R ') GOTO 115
        IF(P.NE.'E ') GOTO 120
C ERASE THE MARK IF E WAS TYPED
        DO 112 I=1,3
112     CALL DLINE(255,Y1-2+I,X1-1,3,0,-1)
        GOTO 25
115     CALL UDLR(PAR)
C CHECK FOR UP,DOWN,LEFT, OR RIGHT
        GOTO 110
120     CONTINUE
        CALL CURSOR(Y2,X2,EL,ES)
        CALL ADL(SL,SS,EL,ES,SST,NST,NL,NS)
        DO 135 L=SL,EL
        Y=2*(L-1)
        X=2*(SST(L)-1)
135     CALL DLINE(LIGHT,Y,X,NST(L),1,0)
140     CALL PARAM(NP,PAR,10)
        IF(IV(BPAR(1)).NE.ERASE) GOTO 150
C RESTORE THE DATA IF E WAS TYPED
        DO 155 L=SL,EL
        Y=2*(L-1)
        X=2*(SST(L)-1)
155     CALL DLINE(127,Y,X,NST(L),1,-1)
        GOTO 25
158     RERUN=1
        DO 175 L=SL,EL
        CALL GET(A,L,IB)
        CALL PUT(A,L,IA)
        IF(IA.NE.IB) PAUSE 55
175     CALL ITLA(0,A(IA+SST(L)),NST(L))
C WRITE ZEROES IN THE DATA SET
        GOTO 30
```

```
C
C       J - JOIN TWO PIECES TOGETHER
C
200     CONTINUE
        CALL CURSOR(Y1,X1,SL,SS)
        CALL TYPE('+MOVE CURSOR TO END OF JOIN ',0)
        DO 205 I=1,3
205     CALL DLINE(255,Y1-2+I,X1-1,3,0,-1)
C MARK END-POINT
210     CALL PARAM(NP,PAR,10)
        IF(NP.EQ.0) GOTO 220
        P=PAR(1)
        IF(P.EQ.'U '.OR.P.EQ.'D '.OR.P.EQ.'L '.OR.P.EQ.'R ') GOTO 215
        IF(P.NE.'E ') GOTO 220
C ERASE THE MARK IF E WAS TYPED
        DO 212 I=1,3
212     CALL DLINE(WHITE,Y1-2+I,X1-1,3,0,0)
        GOTO 25
215     CALL UDLR(PAR)
        GOTO 210
220     CONTINUE
        CALL CURSOR(Y2,X2,EL,ES)
        CALL ADL(SL,SS,EL,ES,SST,NST,NL,NS)
        DO 235 L=SL,EL
        Y=2*(L-1)
        X=2*(SST(L)-1)
235     CALL DLINE(127,Y,X,NST(L),1,-1)
C ERASE ON THE GRAY SCALE TO INDICATE THE JOIN LINE
240     CALL PARAM(NP,PAR,10)
        IF(IV(PAR(1)).NE.ERASE) GOTO 250
        DO 255 L=SL,EL
        S=SST(L)
        CALL GET(A,L,IA)
255     CALL DLINE(A(IA+S),2*(L-1),3*(S-1),NST(L),1,0)
C REWRITE THE DATA
        GOTO 25
250     RERUN=1
        DO 275 L=SL,EL
        CALL GET(A,L,IA)
        CALL PUT(A,L,IA)
275     CALL ITLA(127,A(IA+SST(L)),NST(L))
C WRITE 127 IN THE DATA SET FOR THE JOIN LINE
        GOTO 30
C
C       B - CHANGE BACKGROUND
C
300     CONTINUE
        CALL CURSOR(Y,X,L,S)
        CALL GET(A,L,IA)
        CALL OUTCON(IV(A(IA+S)),MB(7),3)
        IT=(L/LPS)*NC+S/SPS+1
        IF(S/SPS.EQ.NC) IT=IT-1
        CALL OUTCON(TTAB(68+IT),MB(16),3)
        CALL TYPE(MB,0)
        BORT=68
C SET TO CHANGE BACK
320     CALL PARAM(NP,PAR,10)
        IF(NP.EQ.0) GOTO 25
        IF(NP.GT.1) GOTO 35
        IF(PAR(1).GT.127.OR.PAR(1).LT.0) GOTO 60
        TTAB(BORT+IT)=PAR
        CALL GET(A,SPAR(1)+1,IA)
        CALL PUT(A,SPAR(1)+1,IA)
        CALL MVW(TTAB,A(IA+1),133)
        RERUN=1
        GOTO 25
C
C       T - CHANGE THRESHOLD
C
400     CONTINUE
        IF(IV(MT(7)).NE.IV('*')) GOTO 440
C GOTO 440 IF T WAS ALREADY REQUESTED
C DISPLAY THE SECTOR BOUNDARIES
        DO 410 L=LPS,NL,LPS
410     CALL DLINE(WHITE,L+L,NS+NS,8,1,0)
```

```
            CALL ITLA(127,BLACK,512)
            DO 415 S=SPS,NS,SPS
  415       BLACK(S)=8
            DO 420 I=1,5
  420       CALL DLINE(BLACK,NL+NL+I+I-2,8,NS,1,0)
  440       CONTINUE
            CALL CURSOR(Y,X,L,S)
            CALL GET(A,L,IA)
            CALL OUTCON(IV(A(IA+S)),MT(7),3)
            IT=(L/LPS)*NC+S/SPS+1
            IF(S/SPS.EQ.NC) IT=IT-1
            CALL OUTCON(TTAB(4+IT),MT(18),3)
            CALL TYPE(MT,8)
            BORT=4
C SET TO CHANGE THRESH
            GOTO 320
C
C       A - ABORT
C
  500       CONTINUE
            CALL APHASE(0)
            RERUN=0
            GOTO 1000
  600       CONTINUE
C
C F - FINISH KEYWORD
C
            IF(NFLAG.NE.0) GOTO 610
C IF NOB WILL BE CALLED GOTO 610
            CALL APHASE(MASKPH)
            CALL CLOSE(A)
            CALL AFILE(A,1,'PIC       ',5,5)
            CALL OPEN(A,512,0,2,'NOB')
C SET TO ADD NK TO NOB OUTPUT LABEL
            GOTO 620
  610       CONTINUE
            FI=0
            CALL WPARAM(122,NK,NOBPH)
C SET NOB TO CALL MASK AND NOT PUT UP THE DISPLAY
            CALL APHASE(NOBPH)
  620       IF(NP.EQ.3) NK=PAR(3)
C USE OPERATOR SUPPLIED COUNT
            CALL OUTCON(NK,GMSG(68),4)
C CONVERT NK FOR GMSG
            CALL MVL(GMSG,TEMP,68)
            TEMP(25)="50:2
C INSERT LF LF
            CALL TYPE(TEMP,70)
            CALL GLABEL(A,SPAR,IA)
            CALL MVL(GMSG(67),A(IA+290),2)
            CALL PLABEL(A,SPAR,A(IA+1))
C INSERT NK IN THE LABEL
  630       CALL CLOSE(A)
            CALL AFILE(A,4,'PDATA     ',6,6)
            CALL OPEN(A,512,0,2,'PRP')
            CALL GLABEL(A,SPAR,IA)
            NL=NL+1
            CALL PLABEL(A,SPAR,A(IA+1))
            CALL GET(A,NL,IA)
            CALL MVL(GMSG,A(IA+1),128)
            CALL PUT(A,NL,IA)
            PAR(1)='KG'
            PAR(3)=DUNIT
            CALL MVL(FILPEX,PAR(4),10)
            CALL WPARAM(8,PAR,MASKPH)
            CALL CLOSE(A)
            CALL EXIT
  700       CALL SC
            GOTO 25
C
C DISPLAY THE RAW SCAN WITHOUT OBJECT NUMBERS
C
  800       CALL DCLEAR
            FI=64
            MT(7)='*'
```

```
C RESET THRESH INDICATOR
      DO 820 L=1,NL
      CALL GET(A,L,IA)
820   CALL DLINE(A(IA+1),2*(L-1),0,NS,1,0)
      CALL DCOUNT(NK,FI)
      GOTO 25
C
C DISPLAY THE NOB OUTPUT
C
850   FI=64
      CALL WPARAM(122,NK,NOBPH)
      CALL APHASE(NOBPH)
      CALL CLOSE(A)
      CALL EXIT
900   CALL MCU
      GOTO 25
910   CALL MCD
      GOTO 25
920   CALL MCL
      GOTO 25
930   CALL MCR
      GOTO 25
940   CONTINUE
C
C INTERACTIVE COUNT
C
945   CALL CURSOR(Y0,X0,L,S)
      DO 947 I=1,NTIME
      CALL CURSOR(Y,X,L,S)
      IF(Y.NE.Y0.OR.X.NE.X0) GOTO 945
947   CONTINUE
C CURSOR HAS NOT MOVED IN A WHILE
      IF(Y.LT.24.AND.X.GT.1000) GOTO 995
C IF UPPER RIGHT GOTO 995
      CALL CURSOR(Y,X,L,S)
      IF(Y.GT.1000.AND.X.GT.1000) GOTO 970
      CALL TYPE(BELL,0)
C RING THE BELL
      NFLAG=1
      IF(NK.LT.60) NK=NK+1
      CALL DCOUNT(NK,FI)
      YTAB(NK)=Y
      XTAB(NK)=X
      LTAB(NK)=L
      STAB(NK)=S
      DO 950 J=1,2
      DO 950 I=1,3
950   CALL DLINE(WHITE,Y-2+I,X-1,3,0,0)
960   CALL CURSOR(Y2,X2,L,S)
      IF(Y2.EQ.Y.AND.X2.EQ.X) GOTO 960
C WAIT FOR CURSOR TO BE MOVED
      GOTO 945
970   CALL OUTCON(NK,MK(6),2)
      CALL TYPE(MK,0)
      IF(NK.LT.2) GOTO 25
C ORDER THE TABLE
      DO 990 N=2,NK
      IF(LTAB(N).GE.LTAB(N-1)) GOTO 990
      LTN=LTAB(N)
      DO 980 J=1,N
      IF(LTN.LE.LTAB(J)) GOTO 985
980   CONTINUE
985   NMOV=N-J
      CALL MVW(LTAB(J),TEMP,NMOV)
      LTAB(J)=LTN
      CALL MVW(TEMP,LTAB(J+1),NMOV)
      CALL MVW(STAB(J),TEMP,NMOV)
      STAB(J)=STAB(N)
      CALL MVW(TEMP,STAB(J+1),NMOV)
990   CONTINUE
      GOTO 25
995   CONTINUE
C ERASE THE LAST SPOT
      DO 997 J=1,2
      DO 997 I=1,3
```

```
997     CALL DLINE(127,YTAB(NK)-2+I,XTAB(NK)-1,3,0,-1)
        IF(NK.GT.0) NK=NK-1
        CALL DCOUNT(NK,FI)
        GOTO 960
1080    CALL CLOSE(A)
        IF(PRERUN.GT.0) CALL APHASE(2)
        CALL EXIT
C
1100    CONTINUE
C
C N PARAMETER - ADD A NUMBER FOR THE MISSING OBJECT
C
        NFLAG=1
        IF(NK.GE.60) GOTO 60
        CALL CURSOR(Y,X,L,S)
        DO 1110 J=1,2
        DO 1110 I=1,5
1110    CALL DLINE(WHITE,Y-3+I,X-2,5,0,0)
        DO 1120 N=1,NK
        IF(L.LT.LTAB(N)) GOTO 1130
1120    CONTINUE
        LTAB(NK+1)=L
        STAB(NK+1)=S
        GOTO 1140
1130    NMOV=NK-N+1
        CALL MVW(LTAB(N),TEMP,NMOV)
        CALL MVW(TEMP,LTAB(N+1),NMOV)
        LTAB(N)=L
        CALL MVW(STAB(N),TEMP,NMOV)
        CALL MVW(TEMP,STAB(N+1),NMOV)
        STAB(N)=S
1140    NK=NK+1
        CALL DCOUNT(NK,FI)
        GOTO 25
1200    CONTINUE
C
C X PARAMETER - REMOVE ONE OF THE NUMBERED OBJECTS
C
        NFLAG=1
        IF(NK.LT.1) GOTO 60
        CALL CURSOR(Y,X,L,S)
        MIN=20
C FIND THE OBJECT CLOSEST TO L,S AND NO MORE THAN 20 AWAY
        DO 1220 N=1,NK
        DIF=IABS(LTAB(N)-L)+IABS(STAB(N)-S)
        IF(DIF.GT.MIN) GOTO 1220
        MIN=DIF
        NMIN=N
1220    CONTINUE
        IF(MIN.EQ.20) GOTO 60
        N=NMIN
        Y=LTAB(N)*2-2
        X=STAB(N)*2-2
        IF(X.LT.7) X=7
        DO 1240 J=1,2
        DO 1240 I=1,9
1240    CALL DLINE(127,Y-5+I,X-7,9,0,-1)
C ERASE THE OLD NUMBER
        NMOV=NK-N
        IF(NMOV.EQ.0) GOTO 1250
        CALL MVW(LTAB(N+1),LTAB(N),NMOV)
        CALL MVW(STAB(N+1),STAB(N),NMOV)
1250    NK=NK-1
        CALL DCOUNT(NK,FI)
        GOTO 25
C
C       Z - ZERO CHROMOSOME COUNT
C
1300    NK=0
        GOTO 25
C
C       Q - QUICK COUNT
C
1350    PAR(1)='TO'
        PAR(3)=-1
```

```
      CALL UPARAM(3,PAR,2)
      CALL APHASE(2)
      CALL UPARAM(122,NK,NOBPH)
      CALL CLOSE(A)
      CALL EXIT
C QUICK COUNT OPTION
C
C     OT - SET OBJECT THRESHOLD
C
1400  CALL MVU(PAR,RPAR(NRP+1),4)
      NRP=NRP+4
      CALL UPARAM(NRP,RPAR,ROBPH)
      RERUN=1
      GOTO 25
      END



C
C     **********
C     *        *
C     *  MOB   *
C     *        *
C     **********
C
C     MOB PROVIDES:
C A)    THE ORIENTATION MECHANISMS.  EACH INPUT OBJECT
C     IS FIRST ENCLOSED IN A MINIMUM ENCLOSING RCTANGLE.  THEN, THE OBJE
C     IS ROTATED INTO TH INDICATED ORIENTATION , MEASURED
C     AND THEN WRITTEN OUT.  MOB ACCUMULATES A CHROMOSOE
C     DIRCTORYE CONTAINING THE RESULTS OF THE MEASUREMENTS
C
      SUBROUTINE MOB
C
      COMMON/C1/NOB,IDIR
      COMMON/C1/CHDIR,SMLBUF,LRGBUF,NS,NL,CUROLN
     COMMON/C1/ SST,EST
      COMMON/C1/SPIOD,SPLTH,SPAREA
C SMALL BUFFER, FOR HOLDING ROTATED, UNMAGNIFIED OBJECT
      BYTE SMLBUF(90,50)
C LARGE BUFFER, FOR HOLDING UNROTATED OBJECT
      BYTE LRGBUF(90,90)
C BUFFER FOR I/O
      BYTE BUF(2124)
      BYTE OBUF(2124)
C NUMBER OF INPUT OBJECTS
      INTEGER NOB
C SYSTEM PARAMETERS
      INTEGER SPAR(5)
      EQUIVALENCE (SPAR(1),NLI),(SPAR(2),NSI)
C PARAMETER DEY FOR DECODING
      INTEGER NKEY,KEY(11)
C ENDPOINT TRACKERS (8 FRACTIONAL BITS)
      INTEGER XMIN,XMAX,YMIN,YMAX,XSMIN,XSMAX,YSMIN,YSMAX
C STARTING & ENDING SAMPLE TABLE
      INTEGER*2 SST(88),EST(88)
C RANDOM AREAS
C RETURN CODE FROM ORIENTATION SUBROUTINE
      INTEGER RCODE
C RADIANS/DEGREE
      REAL RPD
C OPERATOR SPECIFIED CENTROMERE POSITION
      INTEGER OPCEN(60)
C OPERATOR FLIP FLAG
      LOGICAL OPFLIP(60)
C OPERATOR SPECIFIED ROTTATION
      INTEGER OPROT(60)
C CENTROMERE LOCATION METHOD
      INTEGER CLMETH
C SKELETON FLAG
      LOGICAL SKFLG
C SKELETON SWITCH
      LOGICAL SWSK
C SKELETON ROUTINE PARAMETERS
```

```
      INTEGER SKMIN,SKDELT
C PI & PI/2
      REAL PI,PIHALF
C DELTA THETA
      REAL DELTA
      LOGICAL L4
      INTEGER SEGLTH
      INTEGER BLK,BS,SL
C CURRENT OUTPUT LINE #
      INTEGER CUROLN,BL,CHRENT
C     PARAMETER AREA
      INTEGER PAR(500)
      EQUIVALENCE (PAR,LRGBUF)
C
C INPUT DIRECTORY
C
      INTEGER IDIR(4,60)
C FIRST BLOCK WRITTEN
      INTEGER FBW
C MINIMUM LINE
      INTEGER ML
C MINIMUM SAMPLE
      INTEGER MS
C LAST BLOCK WRITTEN
      INTEGER LBW
C
C CHROMOSOME DIRECTORY AND ITS FORMAT
C
      INTEGER CHDIR(15,60)
C BLOCK NUMBER OF 1ST LINE OF OBJECT
      INTEGER BLKNO
C NUMBER OF SAMPLES IN OBJECT
      INTEGER DIRNS
C NUMBER OF LINES IN OBJECT
      INTEGER DIRNL
C LENGTH OF CHRORMOSOME
      INTEGER LENGTH
C INTEGERATED OPTICAL DENSITY
      INTEGER IOD
C CENTROMERIC INDICIES
      INTEGER CIL,CID,CIA
C CENTROMERE LINE NUMBER
      INTEGER CENLIN
C PERIMETER
      INTEGER PERIM
C AREA
      INTEGER AREA
C PERIMETER SQUARED DIVIDED BY AREA
      INTEGER PSQDA
C CENTROMERE LOCATION METHOD
      INTEGER CEMETH
C MINIMUM AND MAXIMUM AREAS FOR CHROMOSOMES
      INTEGER MAXOA,MINOA
C DEGREES/ ROTATION INCREMENT
C SAMPLE ACCUMULATORS
      INTEGER DENA(88),AREAA(88),ACC(176)
      EQUIVALENCE(DENA(1),ACC(1)),(AREAA(1),ACC(89))
C
C TOTAL AREA AND TOTAL DENSITY FOR NORMALIZING
C
      INTEGER TAREA,TDEN
C
C ACCUMULTORS FOR CALCULATING CIA AND CID
C
      INTEGER CDEN,CAREA
C
C SPREAD MEASUREMENTS
C
      REAL SPIOD,SPAREA,SPLTH
C
C SHORT ARM INDICATOR
C
      INTEGER SHRTA
C
C RANDOM AREAS
C
```

```
      INTEGER CEN,CENP1,S,PER
      REAL DPINC
      BYTE EM(28)
C REMEASUREMENT CHROMOSOME SELECTOR
      LOGICAL SELFLG,SEL(60)
C
C DATA STATEMENTS
C
      DATA DPINC/2.8125/
      DATA MAXCHR/60/
      DATA NKEY/11/,KEY/'AR','RO','FL','CI','LW','SK','SP','SE',
     - 'LD','MW','MD'/
      DATA SKMIN/16/,SKDELT/2/
      DATA ID/3/,RPD/.017453/,PI/3.14159/,PIHALF/1.5708/
      DATA FBW/1/,NL/2/,MS/3/,LBW/4/
      DATA DELTA/.05236/
      DATA SKFLG/.FALSE./
      DATA BLKND/1/,DIRNS/2/,DIRNL/3/,LENGTH/4/,IOD/5/,CIL/6/,CID/7/
      DATA CIA/8/,CENLIN/9/,PERIM/10/,AREA/11/,PSQDA/12/,CEMETH/13/
      DATA OPFLIP/60*.FALSE./,OPCEN/60*0/,OPROT/60*0/
      DATA MAXNL/80/,MAXNS/80/,CHRENT/15/
      DATA SELFLG/.FALSE./,SEL/60*.FALSE./
      CALL MVL(' OBJ ** REJECTED  **** ** **',EM,28)
C
C INITIALIZE SPREAD MEASUREMENTS
C
      SPIOD=0
      SPAREA=0
      SPLTH=0
      CUROLN=8
      NC=0
C
C INITIALIIZE CHROMOSOME DIRECTORY
C
      CALL ITIA(0,CHDIR,MAXCHR*CHRENT)
      MINOA=30
      MAXOA=2000
      CLMETH=88
      SWSK=.FALSE.
C DEFAULT IS LW - NO SKELETON AND WIDTH TO LOCATE CENTROMERE
C
C RETRIEVE PARAMETERS AND DECODE
C
95    CALL RPARAM(NP,PAR,500,8)
      IP=1
10    IF(IP.GT.NP) GO TO 50
      IPN=PAR(IP+2)
      DO 12 J=1,NKEY
      IF(PAR(IP).EQ.KEY(J)) GO TO (15,18,21,24,32,40,45,47,51,54,57),J
   12 CONTINUE
C
C INVALID PARAMETER
C
13    CALL TYPE(' *** PARAMETER ERROR')
      GO TO 95
C
C PARAMETER AR - SET MINIMUM & MAXIMUM OBJECT AREA
C
15    MINOA=PAR(IP+2)
      MAXOA=PAR(IP+3)
      IP=IP+4
      GO TO 10
C
C PARAMETER ROTA - ROTATE SPECIFIED OBJECT PRESCRIBED AMOUNT
C
18     IF(IPN.LT.1.OR.IPN.GT.MAXCHR) GO TO 13
       K=PAR(IP+3)/DPINC
       OPROT(IPN)=K*4
   19 IP=IP+4
      GO TO 10
C
C PARAMETER FLIP - FLIP SPECIFIED OBJECT
C
21    IF(IPN.LT.1.OR.IPN.GT.MAXCHR) GO TO 13
```

```
          OPFLIP(IPN)=.TRUE.
        GO TO 25
C
C PARAMETER CIL - SET CENTROMERIC INDEX
24      IF(IPN.LT.1.OR.IPN.GT.MAXCHR) GO TO 13
        OPFLIP(IPN)=.FALSE.
25      OPCEN(IPN)=PAR(IP+3)
        GO TO 19
C
C PARMETER LW - LOCATE CENTORMERE BY WIDTH
C
32      CLMETH=88
        SWSK = .FALSE.
        IP=IP+2
        GO TO 10
C
C PARAMETER SK - OUTPUT SKELETON PICTURES
C
40      SKFLG=.TRUE.
        IP=IP+2
        GO TO 10
C
C PARAMETER SP - SET SKELETON PARAMETERS
C
45      SKMIN=PAR(IP+2)
        SKDELT=PAR(IP+3)
        IP=IP+4
        GO TO 10
C
C PARAMETER SE - SELECT CHROMOSOMES FOR REMEASUREMENT
C NOTE - THIS PARAMETER ASSUMES THAT A CHROMOSOME DIRECTORY
C EXISTS FROM PREVIOUS MOBBING ON RCR
C
47      K=PAR(IP+2)
        IF(K.LT.1.OR.K.GT.60) GO TO 13
        SELFLG=.TRUE.
        IP=IP+3
        DO 48 M=1,K
        L=PAR(IP)
        IP=IP+1
        SEL(L)=.TRUE.
48      CONTINUE
        GO TO 10
C
C PARAMETER LD - LOCATE CENTROMERE BY DENSITY
C
51      CLMETH=0
        SWSK = .FALSE.
        IP=IP+2
        GO TO 10
C
C PARAMETER MW - LOCATE CENTROMERE USING WIDTH AND MODEL(SKELETON)
C
54      CLMETH = 88
        IP=IP+2
        SWSK=.TRUE.
        GO TO 10
C
C PARAMETER MD - LOCATE CENTROMERRE USING DENSITY AND MODEL(SKELETON)
C
57      CLMETH =0
        IP=IP+2
        SWSK=.TRUE.
        GO TO 10
C
C OPEN DATA SETS
C
59      CALL AFILE(BUF,5,'UCR      ',*13,*13)
        CALL AFILE(OBUF,1,'RCR      ',*13,*13)
        CALL OPEN(BUF,1024,1,0,'UCR')
        CALL OPEN(OBUF,1024,1,1,'RCR')
        CALL GLABEL(BUF,SPAR,IB)
        SPAR(1)=125
C PUT MAX NL IN LABEL SO COPY WILL NOT CAUSE F374
        CALL PLABEL(OBUF,SPAR,BUF(IB+1))
```

```
C
C READ IN ROB DIRECTORY
C
      CALL GET(BUF,1,IB)
      CALL MVL(BUF(IB+1),NOB,MAXCHR*8+2)
      CALL GET(BUF,2,IB)
      DO 55 I=1,NOB
55    CHDIR(PERIM,I)=IV2(BUF(IB+241+(I-1)*2))
      IF(.NOT.SELFLG) GO TO 60
C
C READ PREVIOUS MOB RESULTS IF SELECTIVELY RE-MEASUREING
C
      CALL GET(OBUF,1,IB)
      CALL MVL(OBUF(IB+3),SPIOD,12)
      CUROLN=IV2(OBUF(IB+15))
      NC=IV2(OBUF(IB+17))
      CALL MVL(OBUF(IB+31),CHDIR(1,1),2*15*30)
      CALL GET(OBUF,2,IB)
      CALL MVL(OBUF(IB+31),CHDIR(1,31),2*15*30)
60    CONTINUE
C
C
C MAIN PROGRAM LOOP - EXECUTED ONCE FOR EACH OBJECT TO BE MEASURED
C
C
      DO 500 N=1,NOB
      IF(.NOT.SELFLG)GO TO 79
      IF(.NOT.SEL(N)) GO TO 500
      SPIOD=SPIOD-CHDIR(IOD,N)
      SPLTH=SPLTH-CHDIR(LENGTH,N)
      SPAREA=SPAREA-CHDIR(AREA,N)
      NC=NC-1
70    CONTINUE
C
C INITIALIZE STORAGE FOR THE OBJECT
C
      CALL ITIA(89,SST,MAXNS)
      CALL ITIA(0,EST,MAXNS)
      CALL ITIA(0,LRGBUF,90*90/2)
      NL=0
      NS=0
C
C READ & PROCESS OBJECT BLOCKS
C
      KK=0
      IL=0
      BL=0
      IFB=IDIR(FBW,N)
      ILB=IDIR(LBW,N)
      MINS=IDIR(MS,N)-1
C
C READ EACH BLOCK ONE BY ONE
C
      DO 145 BLK=IFB,ILB
      CALL GET(BUF,BLK,IB)
      NSEG=IV2(BUF(IB+1))
      II=IB+3
C
C PROCESS EACH SEGMENT WITHIN THE BLOCK
C
      DO 140 I1=1,NSEG
      IF(IL.EQ.IV2(BUF(II))) GO TO 110
      IL=IV2(BUF(II))
      BL=BL+1
      IF(BL.GT.88) GO TO 490
110   BS=IV2(BUF(II+2))-MINS
      IF(BS.LT.0) GOTO 490
C IGNORE POSSIBLE BUG IN FOB OUTPUT DATA ********************
      IF(SST(BL).EQ.89) SST(BL)=BS
      NSAMP=IV2(BUF(II+4))
      IF(NSAMP.GT.88) GO TO 490
      KK=KK+NSAMP
      EST(BL)=BS+NSAMP-1
      IF(EST(BL).GT.MAXNS) GO TO 490
C
```

```
C TRANSFER SEGMENT INTO LRGBUF
C
      CALL MVL(BUF(II+6),LRGBUF(BS,BL),NSAMP)
      IF(NSAMP-(NSAMP/2)*2.NE.0) NSAMP=NSAMP+1
140   II=II+NSAMP+6
145   CONTINUE
C
C REJECT OBJECT IF IT IS TOO SMALL OR TOO LARGE
C
      IF(KK.GT.MAXOA.OR.KK.LT.MINOA) GO TO 490
C
C ORIENT THE OBJECT
C
      CALL ORIOB(LRGBUF,SMLBUF,SST,CHDIR(1,N),BL,OPROT(N),RCODE)
      NS=CHDIR(DIRNS,N)
      NL=CHDIR(DIRNL,N)
      IF(RCODE.NE.0) GO TO 490
      NC=NC+1
C
C BUILD ACCUMULATOR TABLES
C
      CALL ACCSUB(SMLBUF,NL,NS,AREAA,DENA,TAREA,TDEN)
C
C BUILD AND ANALYZE THE SKELETON IF LOCATING
C THE CENTROMERE BY DENSITY
C
      METH=1
C ASSUME OPERATOR SUPPLIED CENTROMERE (SET METH=1)
      CEN=OPCEN(N)
      IF(CEN.NE.0) GOTO 170
C CHECK FOR OPERATOR SUPPLIED CENTROMERE
      METH=0
C SET METH=0 FOR AUTOMATIC CENTROMERE
C     IF(.NOT.SWSK) GO TO 150
C     CALL SKSUB(SMLBUF,NL,NS,LRGBUF,CEN,DENA,SKMIN,SKDELT,CLMETH)
C     IF(CEN.NE.0) GO TO 250
C
C THE PREVIOUS STATEMENTS WERE COMMENTED OUT TO MAKE MORE ROOM
C
C LOCATE CENTROMERE BY ALTERNATE METHOD
C
150   ASSIGN 165 TO LOOP
C
C LOOK FOR CENTROMERE IN MIDDLE HALF OF IMAGE
C
      NS1=(NS-(NS/2)+1)/2
C
C FIND MINIMUM
C
155   CONTINUE
      NS2=NS-NS1+1
      MINA=ACC(NS1+CLMETH)
      CEN=NS1
      DO 160 I=NS1,NS2
      IF(ACC(I+CLMETH).GE.MINA) GO TO 160
      MINA=ACC(I+CLMETH)
      CEN=I
160   CONTINUE
      GO TO LOOP
C
C CENTROMERE HAS BEEN TENTATIVELY LOCATED.  IT IS CORRECT
C IF NOT ONE OF THE ENDPOINTS.  IF IT IS AN ENDPOINT, LOOK
C FOR A CENTROMERE WITH AN INDEX BETWEEN .75 AND .87
C
165   IF(CEN.NE.NS1.AND.CEN.NE.NS2) GO TO 230
      ASSIGN 230 TO LOOP
      NS1=(NS+4)/8+1
      GO TO 155
C
C ADJUST CENTROMERE AS REQUIRED BY OPERATOR
C
170   IF(CHDIR(CENLIN,N).LT.0) CEN=NS-CEN+1
C ADJUST FOR SHORT ARM ON RIGHT ORIGINALLY
      MINA=ACC(CEN+CLMETH)
C LOOK ONE UP AND DOWN TO SEE IF THEY ARE SMALLER
      IF(ACC(CEN+1+CLMETH).LT.MINA) GOTO 180
```

```
      IF(ACC(CEN-1+CLMETH).LT.MINA) CEN=CEN-1
      GOTO 250
180   CEN=CEN+1
      GOTO 250
C
C CHECK FOR DUPLICATE MINIMA AND TAKE AVERAGE IF SO
C
230   J=0
      CENP1=CEN+1
      DO 240 I=CENP1,NS2
      IF(ACC(I+CLMETH).NE.MINA) GOTO 245
240   J=J+1
245   CEN=CEN+J/2
C
C MEASURE THE ARMS
C
250   CALL DPT(SMLBUF,NL,CEN,LD2)
      CALL DPT(SMLBUF,NL,1,LD1)
      CALL DPT(SMLBUF,NL,NS,LD3)
      A1LTH=SQRT((CEN-.5)**2+(FLOAT(LD2-LD1))**2)
      A2LTH=SQRT((NS-CEN+.5)**2+(FLOAT(LD3-LD2))**2)
      CHRLTH=A1LTH+A2LTH
      ICMR=100.*A1LTH/CHRLTH+.5
      SHRTA=1
      IF(OPCEN(N).EQ.0) GOTO 260
C FIND SHORT ARM FOR OPERATOR SUPPLIED CENTROMERE
      IF CHDIR(CENLIN,N).LT.0) SHRTA=-1
      IF(OPFLIP(N)) SHRTA=-SHRTA
      GOTO 265
260   IF(ICMR.GE.50) SHRTA=-1
265   IF(ICMR.LT.50) ICMR=100-ICMR
      IF(ICMR.GT.99) ICMR=99
C
C CALCULATE CID AND CIA
C
      CDEN=0
      CAREA=0
      DO 270 I=1,CEN
      CDEN=CDEN+DENA(I)
270   CAREA=CAREA+AREAA(I)
      IDR=((200.*CDEN)-(100.*DENA(CEN))+FLOAT(TDEN))/(2.*TDEN)
      IF(IDR.LT.50) IDR=100-IDR
      IF(IDR.GT.99)IDR=99
      IAR=((200.*CAREA)-(100.*AREAA(CEN))+FLOAT(TAREA))/FLOAT(TAREA+TAREA)
      IF(IAR.LT.50) IAR=100-IAR
      IF(IAR.GT.99) IAR=99
C
C ADD MEASUREMENTS TO CHROMOSOME DIRECTORY
C
      IF(SHRTA.EQ.-1) CEN=CEN-NS-1
C STORE NEGATIVE CEN TO FLAG SHORT ARM ON RIGHT
      CHDIR(CENLIN,N)=CEN
      CHDIR(LENGTH,N)=CHRLTH+.5
      CHDIR(IOD,N)=TDEN
      CHDIR(AREA,N)=TAREA
      CHDIR(CIL,N)=ICMR
      CHDIR(CIA,N)=IAR
      CHDIR(CID,N)=IDR
      FPER=CHDIR(PERIM,N)
      FPSDA=(FPER*FPER)/(TAREA-.5*FPER)
      IF(FPSDA.GT.327.) FPSDA=327.
C CHECK FOR INTEGER OVERFLOW
      CHDIR(PSQDA,N)=100.*FPSDA
      CHDIR(CEMETH,N)=METH
C
C ADD INDIVIDUAL MEASUREMENTS TO SPREAD MEASUREMENTS
C
      SPIOD=SPIOD+TDEN
      SPAREA=SPAREA+TAREA
      SPLTH=SPLTH+CHRLTH
C
C STAND CHROMOSOME UP AND WRITE IT INTO ROTATED FILE
C
      IP=NS
      LPB=1024/NL
      CHDIR(BLKNO,N)=CUROLN
```

```
300     CALL PUT(OBUF,CUROLN,IB)
        CUROLN=CUROLN+1
        IF(SKFLG) GO TO 305
        CALL CHROUT(SMLBUF,OBUF(IB+1),NS,NL,LPB,IP,SHRTA,90)
        GO TO 310
305     CALL CHROUT(LRGBUF,OBUF(IB+1),NS,NL,LPB,IP,SHRTA,90)
310     CONTINUE
        IF(IP.NE.0) GO TO 300
        GO TO 500
C
C OBJECT BYPASSED
C
490     CONTINUE
        CHDIR(BLKNO,N)=0
        CALL OUTCON(N,EM(7),2)
        CALL OUTCON(KK,EM(22),4)
        CALL OUTCON(NL,EM(25),2)
        CALL OUTCON(NS,EM(28),2)
        CALL TYPE(EM,28)
C
C END OF MAIN LOOP
C
500     CONTINUE
C
C UPDATE CHROMOSOME DIRECTORY ON DISC
C
        CALL PUT(OBUF,1,IB)
        CALL ITL2(NOB,OBUF(IB+1))
        CALL ITL2(CUROLN,OBUF(IB+15))
        CALL ITL2(NC,OBUF(IB+17))
        CALL MVL(SPIOD,OBUF(IB+3),12)
        CALL MVL(CHDIR(1,1),OBUF(IB+31),2*30*15)
        CALL PUT(OBUF,2,IB)
        CALL MVL(CHDIR(1,31),OBUF(IB+31),2*30*15)
        CALL CLOSE(OBUF)
        CALL CLOSE(BUF)
C
C MEASUREMENTS COMPLETED
C
999     CONTINUE
        CALL EXIT
        END


C
C**********
C*        *
C* CLASFY *          COMPILE WITH /CO:25          **********
C*        *
C**********
C
C
C CLASFY PROVIDES THE CLASSIFICATION MECHANISM FOR THE CLINICLA
C ALMS SYSTEM.  ITS INPUT IS THE CHROMOSOEM DIRCTORY PRODUCED BY NOB
C AND ITS OUTPUT CONSISTS OF THE RESULTS OF THE CLASSIFICATION PRO-
C CEDURE WHICH IS UTILIZED BY KTYPE TO PRODUCE THE KARYOGRAM
C
C
        SUBROUTINE CLASFY
        COMMON/C1/IIG,CIG,OFG,ICTB,ILTB
        COMMON/C1/NOB,SPIOD,SPLTH,SPAREA,CHDIR,IOBUF
        COMMON/C1/NSO,NFLAG,GID,SID4,ISR,OFS,SCLT,SCS
C
C COMMON REGION
C
C NUMBER OF CHROMOSOMES
C
        INTEGER NOB
C
C CHROMOSOME DIRECTORY
C
        INTEGER CHDIR(15,60)
C
C FORMAT OF DIRECTORY
C
C BLOCK NO. OF FIRST BLOCK OF AN OBJECT
```

```
      INTEGER BLKNO
C NUMBER OF LINES IN OBJECT
      INTEGER DIRNL
C NUMBER OF SAMPLES IN OBJECT
      INTEGER DIRNS
C CHROMOSOME LENGTH
      INTEGER LENGTH
C  INTEGERATED OPTICAL DENSITY
      INTEGER IOD
C CENTROMERIC INDEX BY LENGHT
      INTEGER CIL
C CENTROMERIC INDEX BY DENSITY
      INTEGER CID
C CENTROMERIC INDEX BY AREA
      INTEGER CIA
C CENTROMERE LINE NUMBER IN ORIGINAL PICTURE
      INTEGER CENLIN
C PERIMETER
      INTEGER PERIM
C AREA OF CHROMOSOME
      INTEGER AREA
C PERIM**2/AREA
      INTEGER PSQDA
C # OF DIRECTORY ENTRIES FOR EACH CHROMOSOME
      INTEGER CHRENT
C
C IO BUFFER
C
      BYTE IOBUF(4200)
C
C RANDOM AREAS
C
      INTEGER SPAR(10)
      BYTE ICIL(27)
      INTEGER SLSIZ,RECSIZ,OFSF,SEX
      INTEGER SCSFLG
      INTEGER GNAM(20)
      BYTE MMSG(29),FMSG(36),SMSG(39),PEM(22)
      INTEGER KG(10),JG(10),IG(10),KFAIL(10),JFAIL(10)
      INTEGER CT(20,51),MCT(20,51),MAC(10),MAL(10)
      REAL ST(11)
      INTEGER IST(12),NOG(11),OLDS(50),NEWS(50)
      INTEGER SCS(90),SCLT(5),XTBL(48),ISR(6),CIG(11),IIG(11)
      INTEGER SID4(90),OFG(275),ICTB(60),ILTB(60)
      INTEGER AC(10),AL(10),MING(10),MAXG(10),CTAB(6)
      INTEGER OFS(91),PAR(900),KEY(19)
      LOGICAL GID(10)
      INTEGER YINT(275),YID,BID
      LOGICAL DEBUG,NOX
C
C DATA STATEMENTS
C
      DATA NG/10/,NG1/11/,NG2/12/,NGT2/20/,NGT2M1/19/,YID/'Y '/
      DATA BID/'  '/,ST/6*20 ,2* 25,-1 ,2*20 ,7/0 /
      DATA CT/120*0,18*0,68,99,18*0,68,99,16*0,
      150,67,68,99,16*0,50,67,68,99,
      116*0,59,67,68,99,14*0,62,82,50,67,68,99,14*0,62,84,50,67,68,
      299,10*0,85,99,57,67,62,84,50,67,81,99,10*0,85,99,55,67,62,84,
      350,63,81,99,19*0,81,99,54,67,62,84,50,59,12*0,80,99,54,67,
      462,81,50,57,12*0,80,99,54,67,62,81,50,56,10*0,50,79,80,99,
      554,67,62,81,4*0,8*0,50,79,80,99,54,64,14*0,50,79,80,99,16*0,
      650,79,80,99,16*0,50,79,80,99,16*0,50,79,80,99,16*0,50,79,
      799,99,14*0,70,79,50,79,80,99,12*0,50,59,70,79,53,79,14*0,
      850,59,68,79,53,70,14*0,50,59,68,79,56,68,14*0,50,59,68,79,
      956,68,14*0,50,59,68,79,58,68,12*0,58,67,50,59,68,79,58,68,10*0,
      150,56,58,67,50,59,68,79,58,68,10*0,50,56,58,67,50,59,68,
      179,58,68,10*0,50,56,55,67,50,59,68,79,12*0,50,56,55,67,50,
      159,68,79,12*0,50,56,55,67,50,56,68,79,12*0,50,56,55,67,50,
      156,68,79,12*0,50,56,55,67,16*0,50,56,55,67,16*0,50,57,55,67,
      116*0,50,57,55,67,16*0,50,57,55,67,16*0,50,57,55,67,16*0,
      150,57,55,67,16*0,50,57,55,67,16*0,50,57,55,67,16*0,50,57,
      155,67,16*0,50,57,55,67,16*0,50,57,38*0/
      DATA MCT/100*0,18*0,70,99,18*0,70,99,18*0,70,99,18*0,70,99,
      9  18*0,70,99,18*0,70,99,16*0,50,66,70,99,14*0,53,70,50,66,2*0,
      3  14*0,53,70,50,66,14*0,50,60,53,70,50,66,2*0,
      5  12*0,50,60,53,70,50,66,12*0,68,99,50,60,53,70,50,66,2*0,
```

```
     7 8*0,50,75,68,99,50,60,14*0,50,75,68,99,50,60,6*0,
     9 8*0,50,75,68,99,8*0,8*0,50,75,68,99,8*0,
     1 8*0,50,75,68,99,16*0,50,75,68,99,8*0,
     3 8*0,50,75,68,99,8*0,6*0,68,78,50,75,10*0,
     5 4*0,50,60,68,78,50,69,12*0,63,71,50,60,68,78,60,68,10*0,
     7 0,0,63,71,50,60,68,78,60,68,12*0,63,71,50,60,68,78,60,68,10*0,
     9 50,65,63,71,50,60,68,78,60,69,10*0,
     9 50,65,63,71,50,60,68,78,12*0,
     1 50,65,63,71,50,60,68,78,12*0,50,65,18*0,
     3 50,65,18*0,50,65,18*0,50,65,18*0,50,65,18*0,
     7 50,65,18*0,50,65,18*0,50,65,18*0,50,65,18*0,200*0/
     DATA MAC/60,66,57,72,65,75,56,67,57,88/
     DATA MAL/34,29,27,27,21,19,16,15,13,8/
     DATA IST/1,5,9,13,19,37,45,49,55,65,75,91/,NOC/11*0/
     DATA SLSIZ/0/,SCSFLG/0/,MAXNSO/512/,NSMOV/0/
     DATA GNAM/'A1','  ','A2','  ','A3','  ','B ','  ','C ','  ',
     1'D ','  ','E1','6 ','E ','  ','F ','  ','G ','  '/
     DATA XTBL/1,2,5,6,9,10,13,14,15,16,19,20,21,22,23,24,25,
     126,27,28,29,30,31,32,33,34,37,38,39,40,41,42,45,46,
     249,50,51,52,55,56,57,58,65,66,67,68,69,70/
     DATA AC/52,61,54,73,66,89,58,72,57,89/
     DATA AL/40,38,31,29,23,18,17,15,13,10/
     DATA MING/2,2,2,4,15,6,2,4,4,4/
     DATA MAXG/2,2,2,4,16,6,2,4,4,5/
     DATA CTAB/100,0,0,0,0,100/
     DATA NOX/.FALSE./DEBUG/.FALSE./,RECSIZ/1024/
     DATA BLKNO/1/,DIRNL/2/,DIRNS/3/,LENGTH/4/,IOD/5/,CIL/6/
     DATA CID/7/,CIA/8/,CENLIN/9/,PERIM/10/,AREA/11/,PSQDA/12/
     DATA CHRENT/15/
     DATA OFSF/0/,NSOF/0/,SEX/0/,NKEY/19/
     ISR(1)=1
     ISR(2)=19
     ISR(3)=37
     ISR(4)=55
     ISR(5)=73
     ISR(6)=91
     DO 12 I=1,5
12   SCLT(I)=30
     GID(1)='A-'
     GID(2)='B '
     GID(3)='C '
     GID(4)='  '
     GID(5)='D-'
     GID(6)='E '
     GID(7)='F-'
     GID(8)='G '
     GID(9)='U '
     GID(10)='  '
     CALL MVL('A-1      A-2      A-3      B-4 B-5      C-6 C-7 C-8
     1C-9 C-10C-11C-12  X      B-13D-14D-15     E-16     E-17
     1E-18     F-19F-20              G-21G-22  Y
     1                                                  ',SID4,180)
     CALL MVL('  SIMPLE MOVE FROM *** TO ***',MMSG,29)
     CALL MVL(' COMPLEX MOVE FROM *** TO *** FAILED',FMSG,36)
     CALL MVL(' N=    IC=    IL=    GROUP=    ',ICIL,27)
     CALL MVL(' COMPLEX MOVE FROM *** TO *** SUCCEEDED',SMSG,39)
     CALL MVL('CTSTMIMXCSCLIRIGOSCONNSOSIMAFENXDESZMV',KEY,30)
     CALL MVL('0*** PARAM ERR, IP= ***',PEM,22)
     NLO=0
     NSO=460
C NLO AND NSO ARE DETERMINED AUTOMATICALLY, BUT A LARGER NSO IS OK
C
C GET PARAMETERS
C
990  CONTINUE
     CALL RPARAM(NP,PAR,500,9)
     IP=1
  10 CONTINUE
     IF(IP.GT.NP) GOTO 70
     DO 20 J=1,NKEY
     IF(PAR(IP).EQ.KEY(J)) GOTO(1,2,3,4,5,6,7,8,9,15,
    X 1100,1200,1300,1400,1500,1510,1520,1530,1540),J
  20 CONTINUE
C
C PARAMETER ERROR
```

```
C
   25 CALL OUTCON(IP,PEM(22),3)
      CALL QPRINT(PEM,22)
        GO TO 990
C
C PARAMETER CT - ADJUST THE DECISOIN TABLE
C
    1 IL=PAR(IP+2)+1
      IF(IL.LT.1.OR.IL.GT.51) GOTO 25
      DO 1000 I=1,NGT2
 1000 CT(I,IL)=0
      IP=IP+3
 1010 IF(IP.GT.NP) GOTO 70
      DO 1020 J=1,NG
      IF(PAR(IP).EQ.GNAM(J)) GOTO 1030
 1020 CONTINUE
      GOTO 10
 1030 JJ=J+J
      CT(JJ,IL)=PAR(IP+3)
      CT(JJ-1,IL)=PAR(IP+2)
      IP=IP+4
      GOTO 1010
C
C PARAMETER NN - NO OBJECT NUMBERS OR CENTROMERE FLAG
C
 1100 NFLAG=1
      IP=IP+2
      GOTO 10
C
C PARAMETER SO - SET # OF OUTPUT SAMPLES
C
 1200 NSO=PAR(IP+2)
      NSOF=1
 1203 IP=IP+3
      GOTO 10
C
C PARAMETER SI - SET SLOT ID'S
C
 1300   DO 1310 I=1,90
 1310 SID4(I)=PAR(IP+1+I)
      IP=IP+47
      GOTO 10
C
C PARAMETER MA - MALE KARYOTYPE
C
 1400 SEX=1
 1410 IP=IP+2
      GOTO 10
C
C PARAMETER FE - FEMALE KARYOTYPE
C
 1500 SEX=2
      GOTO 1410
C
C PARAMETER NX - NO X SEPARATION FROM C GROUP
C
 1510 NOX=.TRUE.
        CALL MVL(' B   B              (  C +  X  )
     1 D   D   D     E-16    E   E
     2 F   F               G   G  ',SID4(13),112)
      GOTO 1410
C
C PARAMETER DE - DEBUG OPTION ON
C
 1520 DEBUG=.TRUE.
      GOTO 1410
C
C PARAMETER SZ - SET SLOT SIZE
C
 1530 SLSIZ=PAR(IP+2)
      GOTO 1203
C
C PARAMETER MV - MOVE CHROMOSONES AROUND FROM PREVIOUS KARYOTYPE
C
 1540 IF(NSMOV.LT.50) NSMOV=NSMOV+1
      OLDS(NSMOV)=PAR(IP+2)
      NEWS(NSMOV)=PAR(IP+3)
```

```
      IP=IP+4
      GOTO 10
C
C PARAMETER ST - SET SLOPE TABLE
C
2     DO 2000 I=1,NGT2M1
2000  ST(I)=PAR(IP+1+I)/PAR(IP+2+I)
      IP=IP+NGT2M1+2
      GOTO 10
C
C PARAMETER MI - SET MINIMUM # OF CHROMS. FOR EACH GROUP
C
    3 DO 3300 I=1,NG
 3300 MING(I)=PAR(IP+1+I)
      IP=IP+NG2
      GOTO 10
C
C PARAMETER MX - SET MAXIMUM # OF CHROMS. FOR EACH GROUP
C
    4 DO 4000 I=1,NG
 4000 MAXG(I)=PAR(IP+1+I)
      IP=IP+NG2
      GOTO 10
C
C PARAMETER CS - SET CENTER SAMPLES FOR EACH SLOT
C
    5 DO 5000 I=1,90
 5000 SCS(I)=PAR(IP+1+I)
      SCSFLG=1
      IP=IP+92
      GOTO 10
C
C PARAMETER CL - SET CENTER LINE FOR EACH GROUP
C
    6 DO 6000 I=1,5
 6000 SCLI(I)=PAR(IP+1+I)
      IP=IP+7
      GOTO 10
C
C PARAMETER IR - SET INITIAL SLOT FOR EACH ROW
C
    7 DO 7000 I=1,6
 7000 ISR(I)=PAR(IP+1+I)
      IP=IP+8
      GOTO 10
C
C PARAMETER IG - SET INITIAL SLOT FOR EACH GROUP
C
    8 DO 8000 I=1,NG2
 8000 IST(I)=PAR(IP+1+I)
      IP=IP+NG2+2
      GOTO 10
C
C PARAMETER OS - MANUALLY INSERT CHROMOSOMES INTO SLOTS
C
    9 OFSF=1
      NOFS=NP-IP-1
      IF(NOFS.NE.48.AND.NOFS.NE.46) GOTO 8950
C SEE IF 48 OR 46 OFS PARAMETERS WERE USED
      DO 8900 I=1,NOFS
 8900 OFS(XTBL(I))=PAR(IP+1+I)
C ALLOW FOR THE EXTRA SLOTS
      GOTO 70
 8950 CONTINUE
      DO 9000 I=1,90
      IF(IP+1+I.GT.NP) GOTO 70

 9000 OFS(I)=PAR(IP+1+I)
      IP=IP+92
      GOTO 10
C
C PARAMETER CO - ADJUST COEEFICIENTS
C
15      DO 71 I=1,6
        CTAB(I)=PAR(IP+1+I)
```

```
 71       CONTINUE
          IF(CTAB(1)+CTAB(2)+CTAB(3).NE.100) GO TO 900
          IF(CTAB(4)+CTAB(5)+CTAB(6).NE.100) GO TO 900
          GO TO 10
900       CALL TYPE(' *** COEFFICIENT SUM NOT = 100')
          CALL TYPE('0')
          GO TO 990
C
C READ IN CHROMOSOME DIRECTORY
C
 70       CALL AFILE(IOBUF,1,'RCR       ',*13,*13)
          CALL OPEN(IOBUF,1024,1,0,'RCR')
          CALL GLABEL(IOBUF,SPAR,IB)
          LSEX=0
          IF(IOBUF(IB+104).EQ.*115) LSEX=1
          IF(IOBUF(IB+104).EQ.*106) LSEX=2
          IF(IV(IOBUF(IB+82)).NE.*71) GOTO 777
C GOTO 777 IF NOT SOURCE 9, 19, 29, ... (MONKEY)
          CALL MVW(MCT,CT,1020)
C REPLACE HUMAN TABLES WITH MONKEY TABLES FOR SOURCE 9
          CALL MVW(MAC,AC,10)
          CALL MVW(MAL,AL,10)
          MING(10)=0
          MAXG(10)=1
          IST(10)=70
C SET C+Y GROUP FOR POSSIBLE 1
777       CONTINUE
          CALL GET(IOBUF,1,IB)
          CALL MVL(IOBUF(IB+1),NOB,16)
          NC=IV2(IOBUF(IB+17))
          SPLTH=SPLTH*46/NC
          SPIOD=SPIOD*46/NC
          SPAREA=SPAREA*46/NC
          CALL MVL(IOBUF(IB+31),CHDIR(1,1),2*15*30)
          CALL GET(IOBUF,2,IB)
          CALL MVL(IOBUF(IB+31),CHDIR(1,31),2*15*30)
          DO 72 I=1,NOB
          CHDIR(LENGTH,I)=CHDIR(LENGTH,I)*10000./SPLTH
          CHDIR(IOD,I)=CHDIR(IOD,I)*10000./SPIOD
          CHDIR(AREA,I)=CHDIR(AREA,I)*10000./SPAREA
 72       CONTINUE
C
C INITIALIZE CURRENT INDEX AND INITIAL INDEX FOR EACH GROUP
C
        CIG(1)=0
        IIG(1)=1
        DO 75 I=2,NG1
        CIG(I)=CIG(I-1)+25
   75   IIG(I)=IIG(I-1)+25
C
C SET UP SLOT SIZE IF NOT INPUT
C
          IF(SLSIZ.EQ.0) SLSIZ=24
          IF(SLSIZ.GT.28) SLSIZ=28
          IF(SLSIZ.LT.12) SLSIZ=12
        PSEP=SLSIZ/3
C PAIR SEPARATION
        SCS(1)=PSEP+SLSIZ+2
        SCS(2)=SCS(1)+SLSIZ
        DO 752 I=3,17,2
        SCS(I)=SCS(I-1)+SLSIZ+PSEP
  752   SCS(I+1)=SCS(I)+SLSIZ
        DO 756 I=1,18
        DO 754 J=1,4
  754   SCS(18*J+I)=SCS(I)
  756   CONTINUE
  758   CONTINUE
C
C CHECK SEX
C
        IF(SEX.GT.0) GOTO 76
          SEX=LSEX
   76   IF(SEX.NE.1) GOTO 77
C MALE
        MAXG(5)=15
        MING(10)=MING(10)+1
```

```
   77 IF(SEX.NE.2) GOTO 78
C FEMALE
      MING(5)=16
      MAXG(10)=MAXG(10)-1
      IF(SID4(70).EQ.YID) SID4(70)=BID
C CHANGE Y TO BLANK UNLESS SID WAS CHANGED BY USER
   78 CONTINUE
      IF(OFSF.EQ.1) GOTO 403
C
C SKIP CLASSIFICATION IF OFS TABLE IS INPUT
C
C DO INITIAL ASSIGNMENTS OF CHROMOSOMES TO GROUPS
C
      DO 200 N=1,NOB
      IF(CHDIR(BLKNO,N).EQ.0) GO TO 200
      IC=(CHDIR(CIL,N)*CTAB(4)+CHDIR(CID,N)*CTAB(5)+CHDIR(CIA,N)
     1*CTAB(6))/100
      IL=((FLOAT(CHDIR(LENGTH,N))*CTAB(1)+FLOAT(CHDIR(IOD,N))
     1*CTAB(2)+FLOAT(CHDIR(AREA,N))*CTAB(3))/1000.)+1.
      IF(IL.GT.51) IL=51
      CALL OUTCON(N,ICIL(5),-2)
      CALL OUTCON(IC,ICIL(11),-2)
      CALL OUTCON(IL,ICIL(17),-2)
      ICTB(N)=IC
      ILTB(N)=IL
      IF(IC.EQ.0.OR.CHDIR(PSODA,N).LT.1340.OR.CHDIR(AREA,N).GT.600)
     1GO TO 82
C PUT IN UNKNOWN GROUP IF BLOB OR OVERLAP
      DO 80 J=1,NGT2M1,2
      IF(IC.GE.CT(J,IL).AND.IC.LE.CT(J+1,IL)) GOTO 100
C IF IC IS WITHIN THE GROUP LIMITS FOR THIS VALUE OF IL GOTO 100
   80 CONTINUE
   82 J=NG1
C     OBJECT IS IN THE FORBIDDEN ZONE
      GOTO 110
   85 CONTINUE
        CALL TYPE(' ALL SLOTS FULL')
      GOTO 200
  100 CONTINUE
      J=(J+1)/2
  110 CONTINUE
      CALL OUTCON(J,ICIL(26),-2)
        IF(DEBUG) CALL QPRINT(ICIL,27)
      IF(NOG(J).EQ.25) GOTO 85
      NOG(J)=NOG(J)+1
      CIG(J)=CIG(J)+1
      OFG(CIG(J))=N
  200 CONTINUE
C
C IF ANY GROUP IS HEAVY OR LIGHT, TRY TO MOVE CHROMOSOEMS AROUND
C
  210 NFAIL=0
  220 CONTINUE
      KH=0
      NMOV=0
      DO 3000 J=2,NG
      IF(NOG(J).GE.MAXG(J)) GOTO 3000
      K2=J-1
      NCAN=0
      DMIN=100000.
C GROUP J IS LIGHT, SEE IF A PRECEDING GROUP IS HEAVY
      DO 2500 K=1,K2
      IF(NOG(K).LE.MING(K)) GOTO 2500
C GROUP K IS HEAVY
      IF(NFAIL.EQ.0) GOTO 230
      DO 225 N=1,NFAIL
      IF(K.EQ.KFAIL(N).AND.J.EQ.JFAIL(N)) GOTO 235
C THIS J AND K HAS ALREADY FAILED
  225 CONTINUE
  230 KH=K
      JL=J
C SAVE HEAVY AND LIGHT GROUP NUMBERS
  235 CONTINUE
      I1=IIG(K)
      I2=CIG(K)
```

```
      DO 2400 I=I1,I2
      N=OFG(I)
      IC=ICTB(N)
      IL=ILTB(N)
      JJ=J+J
      IF(IC.LT.CT(JJ-1,IL).OR.IC.GT.CT(JJ,IL)) GOTO 2400
C OBJECT IS IN GROUP J, MOST LIKELY IF CLOSE TO CENTER OF J
C AND FAR FROM CENTER OF K
      D = ((IC-AC(J))**2+(IL-AL(J))**2) /
     1 MAX0(((IC-AC(K))**2+(IL-AL(K))**2),1)
      IF(D.GE.DMIN) GOTO 2400
C THIS IS THE MOST LIKELY CANDIDATE SO FAR
      KSAV=K
      ISAV=I
      NCAN=N
      DMIN=D
 2400 CONTINUE
 2500 CONTINUE
      IF(NCAN.EQ.0) GOTO 3000
      NMOV=NMOV+1
C MOVE OBJECT N FROM GROUP KSAV TO GROUP J
       CALL OUTCON(KSAV,MMSG(22),3)
       CALL OUTCON(J,MMSG(29),3)
      IF(DEBUG) CALL QPRINT(MMSG,29)
      NOG(J)=NOG(J)+1
      CIG(J)=CIG(J)+1
      OFG(CIG(J))=NCAN
      CIG(KSAV)=CIG(KSAV)-1
      NOG(KSAV)=NOG(KSAV)-1
      I2=CIG(KSAV)
      DO 2600 I=ISAV,I2
 2600 OFG(I)=OFG(I+1)
C CLOSE UP THE REMAINING OBJECTS IN THE GROUP
 3000 CONTINUE
      IF(NMOV.GT.0) GOTO 220
C IF SOMETHING WAS MOVED, SEE IF MORE MOVES ARE POSSIBLE
      IF(KH.EQ.0) GOTO 3100
C KH IS HEAVY AND JL IS LIGHT BUT NO SIMPLE MOVE WAS POSSIBLE
C SEE IF THERE IS A COMPLEX (MULTI-LEVEL) MOVE THAT CAN BE MADE
      L=1
      JG(1)=JL
 3010 KG(L)=KH
 3020 CALL CFO(KG(L),JG(L),IX,AC,AL,CT)
C CHECK FOR A CHROMOSOME IN THE KG-JG OVERLAP AREA
      IF(IX.EQ.0) GOTO 3040
      IG(L)=IX
C SAVE INDEX NUMBER
      IF(KG(L).EQ.KH) GOTO 3060
C WE NEED TO GO UP ONE LEVEL
      L=L+1
      JG(L)=KG(L-1)
      GOTO 3010
 3040 KG(L)=KG(L)+1
C LOOK AT THE NEXT GROUP ON THIS LEVEL
      IF(KG(L).LT.JG(L)) GOTO 3020
      L=L-1
C GO DOWN ONE LEVEL
      IF(L.GT.0) GOTO 3040
C FAILED TO FIND A GOOD MOVE
      NFAIL=NFAIL+1
      IF(NFAIL.GT.10) GOTO 3100
      KFAIL(NFAIL)=KH
      JFAIL(NFAIL)=JL
       CALL OUTCON(KH,FMSG(22),3)
       CALL OUTCON(JL,FMSG(29),3)
      IF(DEBUG) CALL QPRINT(FMSG,36)
      GOTO 220
 3060 CONTINUE
C MAKE THE L MOVES THAT HAVE BEEN FOUND
      DO 3080 M=1,L
      ISAV=IG(M)
      JGM=JG(M)
      KGM=KG(M)
      NOG(JGM)=NOG(JGM)+1
      CIG(JGM)=CIG(JGM)+1
```

```
      OFG(CIG(JGM))=OFG(ISAV)
      CIG(KGM)=CIG(KGM)-1
      NOG(KGM)=NOG(KGM)-1
      I2=CIG(KGM)
      DO 3070 I=ISAV,I2
 3070 OFG(I)=OFG(I+1)
 3080 CONTINUE
        CALL OUTCON(KH,SMSG(22),3)
        CALL OUTCON(JL,SMSG(29),3)
      IF(DEBUG) CALL QPRINT(SMSG,39)
      GOTO 210
C LOOK FOR MORE MOVES
C
C DONE MOVING CHROMOSOMES BETWEEN GROUPS. NOW ORDER THE CHROMOSOMES
C WITHIN EACH GROUP
C
 3100 CONTINUE
      DO 300 J=1,NG1
      IF(NOG(J).EQ.0) GOTO 300
      I1=IIG(J)
      I2=CIG(J)
      DO 240 I=I1,I2
      N=OFG(I)
      IC=ICTB(N)
      IL=ILTB(N)
      YINT(I)=IC-ST(J)*IL
      IF(ST(J).LT.0) YINT(I)=-YINT(I)
  240 CONTINUE
C STORE Y INTERCEPT
      I1=IST(J)
  242 CONTINUE
      L2=IST(J)+NOG(J)-1
      IF(L2.LT.IST(J+1)) GOTO 246
      NOG(J)=NOG(J)-1
      IF(NOG(NG1).LT.IST(NG2)-IST(NG1)) GOTO 244
        CALL SSWTCH(1,ISW1)
        IF(ISW1.EQ.1) CALL TYPE(' ALL SLOTS FULL')
      GOTO 242
  244 CONTINUE
      CIG(NG1)=CIG(NG1)+1
      NOG(NG1)=NOG(NG1)+1
      OFG(CIG(NG1))=OFG(I2)
      I2=I2-1
      GOTO 242
  246 CONTINUE
      DO 260 L=L1,L2
      MINY=9999
      DO 250 I=I1,I2
      IF(YINT(I).GE.MINY) GOTO 250
      MINY=YINT(I)
      MINI=I
  250 CONTINUE
      OFS(L)=OFG(MINI)
      YINT(MINI)=9999
  260 CONTINUE
C STORE THE GROUP IN ORDER OF YINT
  300 CONTINUE
  310 CONTINUE
C
C NOW MAKE ANY OTHER ADJUSTMENTS REQUIRED
C
      IF(NOX) GOTO 350
C CHECK FOR NO X SEPARATION FROM C GROUP DESIRED
C FIND THE X OR X-X IN GROUP C
      I1=IST(5)
      I2=I1+15
      I3=I1+2
      I4=I2-2
      IF(NOG(5).EQ.16) GOTO 330
      IF(NOG(5).NE.15) GOTO 350
C C HAS 15, THIRD LARGEST IS X
      OFS(I2)=OFS(I3)
      DO 320 I=I3,I4
  320 OFS(I)=OFS(I+1)
      OFS(I2-1)=0
```

```
      GOTO 350
  330 CONTINUE
C C HAS 16, 3 AND 4 ARE X-X
      ITEMP=OFS(I3)
      ITAMP=OFS(I3+1)
      DO 340 I=I3,I4
  340 OFS(I)=OFS(I+2)
      OFS(I2-1)=ITEMP
      OFS(I2)=ITAMP
  350 CONTINUE
      IF(NOG(NG).NE.5.OR.SEX.EQ.2) GOTO 400
C IF 5 IN GROUP G, FIND THE Y CHROMOSOME
      I1=IST(NG)
      I2=I1+4
      IF(OFS(I2).EQ.0) GOTO 400
      MAX=-1
      DO 360 I=I1,I2
      N=OFS(I)
        M=50*CHDIR(AREA,N)/(CHDIR(DIRNL,N)*CHDIR(DIRNS,N))
      IF(M.LE.MAX) GOTO 360
      MAX=M
      IMAX=I
      NMAX=N
  360 CONTINUE
      I4=I2-1
      DO 370 I=IMAX,I4
  370 OFS(I)=OFS(I+1)
      OFS(I2)=0
      OFS(I2+1)=NMAX
  400 CONTINUE
      IF(NSWOV.EQ.0) GOTO 403
      DO 402 N=1,NSWOV
      NEWSN=NEWS(N)
      OLDSN=OLDS(N)
        IF(NEWSN.NE.0) GOTO 401
C DELETE OBJECT IN OLDSN IF NEWSN = 0
        OFS(OLDSN)=0
        GOTO 402
  401   CONTINUE
        NSAVE=OFS(NEWSN)
        OFS(NEWSN)=OFS(OLDSN)
        OFS(OLDSN)=NSAVE
  402 CONTINUE
  403 CONTINUE
C ADJUST TABLE FOR OBJECTS WIDER THAN 24 SAMPLES
      DO 410 J=1,NG1
      I1=IST(J)
      I2=IST(J+1)-1
      IDEL=0
      DO 405 I=I1,I2
      SCS(I)=SCS(I)+IDEL
C ADD ON ANY PREVIOUS DELTA
      INP=OFS(I)
      IF(INP.EQ.0) GOTO 404
        NSTM24=CHDIR(DIRNS,INP)-SLSIZ
      IF(NSTM24.LE.0) GOTO 404
        SCS(I)=SCS(I)+NSTM24/2
C ADD DELTA FOR THIS OBJECT
        IDEL=IDEL+NSTM24
  404   IF(SCS(I).GT.506) SCS(I)=506
  405 CONTINUE
  410 CONTINUE
      IF(NSOF.EQ.1.AND.NSO.EQ.0) GOTO 425
C IF NSO OF 0 WAS SPECIFIED, DO NOT CHANGE IT
C NOW FIND NSO
      DO 420 J=2,6
      DO 415 I=1,18
      INP=OFS(ISR(J)-I)
      IF(INP.EQ.0) GOTO 415
C THIS IS THE LAST NON-VACANT SLOT ON THE ROW
      ITEMP=SCS(ISR(J)-I)+SLSIZ/2+PSEP
      IF(ITEMP.GT.NSO) NSO=ITEMP
C ADJUST NSO IF REQUIRED
      GOTO 420
  415 CONTINUE
```

```
  428 CONTINUE
      IF(NSO.GT.MAXNSO) NSO=MAXNSO
C
C  OUTPUT RESULTS OF CLASSIFICATION
C
425   CONTINUE
      DO 500 I=1,5
      ISRI=ISR(I)
      DO 450 J=1,10
      JJ=ISRI+J-1
      INP=OFS(JJ)
      IF(JJ.GE.ISR(I+1)) INP=0
      IF(INP.EQ.0) GO TO 450
      ITEMP=CHDIR(DIRNL,INP)/2+28
      IF(SCLT(I).LT.ITEMP) SCLT(I)=ITEMP
450   CONTINUE
500   CONTINUE
      CALL PUT(IOBUF,3,IB)
      CALL MVL(NSO,IOBUF(IB+1),2*294)
      CALL CLOSE(IOBUF)
C
C  DOEN RETURN
C
      CALL EXIT
      END


C
C*********
C*       *
C* KTYPE *
C*       *
C*********
C
C  KTYPE PRODUCES THE OUTPUT KARYOGRAM FROM THE CLASSIFICATIONTABLES
C  PRODUCED BY CLASFY AND THE ROTATED CHROMOSOME IMAGES
C  PRODUCED BY ORIENT.
      SUBROUTINE KTYPE
      COMMON/C1/IMVB,IBUF,OBUF,NLT,NST,FBN,CENLIN,CEMETH
      COMMON/C1/NSO,NFLAG,GID,SID,ISR,OFS,SCLT,SCS
      INTEGER SPAR(10),CEMETH(60)
      BYTE IMVB(56)
      INTEGER ISR(6),GID(10),SID(90)
      INTEGER R(39)
      BYTE OBUF(3128),IBUF(20480)
      INTEGER FBN(60),NST(60),NLT(60),CENLIN(60),OFS(91),SCS(90)
      BYTE LABEL(216)
      INTEGER SCLT(5)
      CALL MVL('0 *-*  **  **  **  **  **  **  **  **  **  **  **
     1  **  **  **  **  **  **  **  ',R,78)
C
C
C  OPEN DATA SETS
C
      CALL DCLEAR
C  CLEAR GRAY SCALE
      CALL AFILE(IMVB,1,'RCR      ',*13,*13)
      CALL AFILE(OBUF,5,'PIC      ',*5,*5)
      CALL OPEN(IMVB,1024,0,0,'RCR')
      CALL OPEN(OBUF,1536,1,1,'KGM')
      CALL GLABEL(IMVB,SPAR,IB)
      CALL MVL(IMVB(IB+1),LABEL,216)
      NLO=0
C
C  READ CHROMOSOME DIRECTORY & BUILD TABLES
C
      CALL READ(IMVB,1,IB,IBUF(1))
      NOB=IV2(IBUF(1))
      DO 10 I=1,30
      FBN(I)=IV2(IBUF(1+30*I))
      NLT(I)=IV2(IBUF(3+30*I))
      NST(I)=IV2(IBUF(5+30*I))
      CENLIN(I)=IABS(IV2(IBUF(17+30*I)))
```

```
      CEMETH(I)=IV(IBUF(25+39*I))
      IF (NOB.EQ.I) GO TO 40
10    CONTINUE
      CALL READ(IMVB,2,IB,IBUF(1))
      DO 20 I=1,30
      FBN(I+30)=IV2(IBUF(1+30*I))
      NLT(I+30)=IV2(IBUF(3+30*I))
      NST(I+30)=IV2(IBUF(5+30*I))
      CENLIN(I+30)=IABS(IV2(IBUF(17+30*I)))
      CEMETH(I+30)=IV(IBUF(25+30*I))
      IF(NOB.EQ.I+30)GO TO 40
20    CONTINUE
C
C READ IN CLASSIFICATION TABLES
C
40    CONTINUE
      CALL READ(IMVB,3,IB,IBUF(1))
      CALL MVL(IBUF(1),NSO,2*294)
      IF(NSO.GT.512) GO TO 900
      SPAR(1)=512
      SPAR(2)=NSO
      SPAR(5)=512
      CALL PLABEL(OBUF,SPAR,LABEL)
C
C MAIN LOOP:
C     BUILD EACH ROW OF THE OUTPUT KARYOGRAM
C
      DO 500 I=1,5
      ISRI=ISR(I)
      IF(I.LT.5) GOTO 430
C SEE IF THERE ARE ANY OBJECTS ON ROW 5
      DO 420 J=1,10
      IF(OFS(ISRI+J-1).NE.0) GOTO 430
420   CONTINUE
      GOTO 500
C NO OBJECTS ON ROW 5
430   CONTINUE
      R(2)=GID(1+(I-1)*2)
      R(3)=GID(2+(I-1)*2)
      DO 450 J=1,10
      JJ=ISRI+J-1
      INP=OFS(JJ)
      IF(JJ.GE.ISR(I+1)) INP=0
      CALL OUTCON(INP,R(5+(J-1)*2),-2)
      IF(INP.EQ.0) CALL ITL(32,R(5+(J-1)*2))
450   CONTINUE
      CALL SSWTCH(1,IBIT)
      IF(IBIT.NE.1) GO TO 475
      CALL TYPE(R,78)
C
C INVOKE THE ROW BUILDING ROUTINE
C
475   CONTINUE
      CALL KROW(ISR(I+1)-ISRI,OFS(ISRI),SCLT(I),SCS(ISRI),NSO,
     1SID(ISRI),NFLAG)
      NLO=NLO+2*SCLT(I)
500   CONTINUE
C
C CLOSE UP DATA SETS AND RETURN
C
      SPAR(1)=NLO
      CALL PLABEL(OBUF,SPAR,LABEL)
      CALL CLOSE(IMVB)
      CALL CLOSE(OBUF)
      CALL EXIT
C
C ERROR
C
900   CALL TYPE(' *** NSO TOO BIG')
      CALL TYPE('0')
      CALL EXIT
      END
```

```
      SUBROUTINE KROW(NSL,OFS,SCL,SCS,NSO,SID,NFLAG)
C
C********
C*      *
C* KROW *
C*      *
C********
C
C KROW CONSTRUCTS A ROW OF THE OUTPUT KARYOGRAM.  IT IS INVOKED BY
C KTYPE.
C
      COMMON/C1/IMVB,IBUF,OBUF,NLT,NST,FBN,CENLIN,CEMETH
      INTEGER CENLIN(60),CEMETH(60)
      INTEGER X,Y,REPL
      BYTE CHAR(4)
      INTEGER SCL,SID(90)
      BYTE IMVB(56)
      INTEGER IDT(60)
      INTEGER OFS(91),SCS(90),NLT(60),NST(60),FBN(60)
      INTEGER NSL,NSO,SCL2
      BYTE OBUF(3128),IBUF(20480),L00,LFF
      INTEGER RECSIZ,MAXNSL
      DATA L00/0/,LFF/127/,RECSIZ/1024/,MAXNSL/20/
      DATA X/0/,Y/0/,REPL/1/
C
C RETURN IF NSO=0
C
      IF(NSO.EQ.0) GO TO 910
      IF(NSL.GT.MAXNSL) GO TO 900
C
C SET UP BUFFER INDICIES
C
      IDT(1)=1
      DO 50 I=2,NSL
50    IDT(I)=IDT(I-1)+RECSIZ
      NSO4=(NSO+1)/2
      SCL2=SCL*2
C
C MAIN ROW LOOP - PROCESSES EACH LINE WITHIN THE ROW
C
      DO 200 L=1,SCL2
      CALL PUT(OBUF,0,IO)
      CALL ZIA(OBUF(IO+1),NSO4)
C
C  SLOT LOOP - PROCESSES EACH SLOT WITHIN THE CURRENT LINE
C
      DO 150 I=1,NSL
      N=OFS(I)
      N1=OFS(I+1)
      IF(N.NE.0) GO TO 80
C CHECK FOR FIRST SLOT OF A PAIR EMPTY, BUT SECOND SLOT FULL
      IF(N1.EQ.0) GO TO 150
C GOTO 150 IF BOTH SLOTS ARE EMPTY
      NL2=0
      GO TO 130
C
C DECIDE IF OBJECT APPEARS ON THIS LINE
C
80    CONTINUE
      NLTN=NLT(N)
      NL2=NLTN/2
      IF(L.LT.SCL-NL2.OR.L.GE.SCL+NL2) GO TO 120
      LO=L-SCL+NL2
C
C CALCULATE INITIAL SAMPLE FOR OBJECT ON OUTPUT LINE
C
      NSTN=NST(N)
      NS2=NSTN/2
      IF(SCS(I)+NS2.GT.511) SCS(I)=511-NS2
      IS=SCS(I)-NS2
C
C GET FIRST BLOCK # OF THE OBJECT
C
      IB=FBN(N)
      IF(IB.EQ.0) GO TO 120
```

```
C BYPASS OBJECT IF NOT IN DIRECTORY
      LPBN=RECSIZ/NSTN
      MLO=MOD(LO,LPBN)
      IF(MLO.GT.0) GO TO 90
      CALL READ(INVB,IB+LO/LPBN,IA,IBUF(IDT(I)))
90    J1=IDT(I)+MLO*NSTN
C
C TRANSFER OBJECT SEGMENT INTO THE OUTPUT BUFFER
C
      CALL MVL(IBUF(J1),OBUF(IO+IS),NSTN)
      IS=IS+NSTN
C
C SEE IF THIS IS THE CENTROMERE LINE
C
      IF(NFLAG.NE.0) GO TO 150
      IF(LO.NE.CENLIN(N)-1) GO TO 150
C
C CENTROMERE LINE, FIND WHERE TO PUT THE CENTROMERE ARROWS
C
      IT=IS-NSTN
      ITMAX=IS-1
      DO 110 IU=IT,ITMAX
      IF(OBUF(IO+IU).GT.L00) GO TO 112
110   CONTINUE
      GO TO 117
112   CONTINUE
      IT=IS
115   IT=IT-1
      IF(OBUF(IO+IT).EQ.L00) GO TO 115
117   CONTINUE
      DO 118 K=3,5
      OBUF(IO+IU-K)=LFF
118   OBUF(IO+IT+K)=LFF
      GO TO 150
C
C CHECK TO SEE IF LINE CONTAINS OBJECT #
C
120   CONTINUE
      IF(NFLAG.NE.0.OR.L.LT.SCL-NL2-9.OR.L.GT.SCL-NL2-3) GO TO 130
C
C LINE CONTAINS OBJECT #, SO PUT NUMBER INTO OUTPUT BUFFER
C
      LO=L-SCL+NL2+9
      IS=SCS(I)-11
      IF(IS.GT.500) IS=500
      IF(N.LT.10) IS=IS-3
      NN=N
      IF(CEMETH(N).EQ.1) NN=-N
C FLAG OPERATOR CORRECTED CENTROMERES
      CALL OUTCON(NN,CHAR(3),3)
      CALL TEXT(CHAR,3,LO,OBUF(IO+IS),1)
      GO TO 150
C
C CHECK TO SEE IF LINE CONTAINS GROUP ID
C
130   CONTINUE
      IF(I.EQ.(I/2)*2) GO TO 150
      IF(N1.EQ.0) GO TO 140
      NL3=NLT(N1)/2
      IF(NL3.GT.NL2) NL2=NL3
140   CONTINUE
      IF(L.LT.SCL+NL2+5.OR.L.GT.SCL+NL2+10) GO TO 150
C
C LINE CONTAINS GROUP ID, SO OUTPUT A LINE OF THE ID TO THE OUTPUTBUF
C
      LO=(L-SCL-NL2-5)/2
      IS=((SCS(I)+SCS(I+1))/4)*2-23
      IF(IS.GT.464) IS=464
      CALL TEXT(SID(I),4,LO,OBUF(IO+IS),2)
150   CONTINUE
      IF(Y.LT.1024) CALL DLINE(OBUF(IO+1),Y,X,NSO,REPL,0)
      Y=Y+REPL+1
200   CONTINUE
      RETURN
C
```

```
C BUFFER TOO SMALL TO HANDLE THE ROW
C
900     CONTINUE
        CALL TYPE (' *** BUFFER TOO SMALL FOR ROW')
        CALL TYPE('0')
        RETURN
C
C NSO=0
C
910     CONTINUE
        CALL TYPE(' *** NSO=0')
        CALL TYPE('0')
        RETURN
        END



        SUBROUTINE INT2
C********
C*      *
C* INT2 *
C*      *
C********
C
C THIS ROUTINE IS THE SECOND OPERATOR INTERACTION PHASE.  IT
C ALLOWS THE OPERATOR TO EITHER APPROVE THE KARYOTYPE WHICH IS
C BEING DISPLAYED ON THE GRAY SCALE DEVICE, FOR HARD COPY OUTPUT
C OR ELSE MAKE CHANGES VIA MOB AND/OR CLASFY/KTYPE PARAMETERS.
C
C COMMON REGION
        COMMON/C1/NSO,NFLAG,GID,SID,ISR,OFS,SCLT,SCS
        COMMON/C1/CHDIR,MOB,SPIOB,SPLTH,SPAREA,CUROLN,NC
C I/O BUFFER
        BYTE IOBUF(2124)
C MOB PARAMETERS AND CURRENT PARAMETER HIGH WATER MARK
        INTEGER MOBPAR(500),M,BNDPAR(4)
C CLSFY/KTYPE PARAMETERS AND CURRENT PARM. HIGH WATER MARK
        INTEGER KTYPAR(500),K
C INT2 LOCAL PARAMETER BUFFER AND POINTER
        INTEGER PAR(100),IP
C RE-MOB CHROMOSOME SELECTOR
        LOGICAL SEL(60)
C CLASSIFICATION TABLES
        INTEGER CUROLN
C
C CHROMOSOME DIRECTORY AND ITS FORMAT
C
        INTEGER CHDIR(15,60)
C BLOCK #
        INTEGER BLKNO
C NUMBER OF LINES IN OBJECT
        INTEGER DIRNL
C NUMBER OF SAMPLES IN OBJECT
        INTEGER DIRNS
C LENGTH
        INTEGER LENGTH
C INTEGERATED OPTICAL DENSITY
        INTEGER IOD
C CENTROMERIC INDICIES
        INTEGER CIL,CID,CIA
C CENTROMERE LINE #
        INTEGER CENLIN
C PERIMERE
        INTEGER PERIM
C AREA
        INTEGER AREA
C PERIM SQUARED DIVIDED BY AREA
        INTEGER PSQDA
C CENTROMERE LOCATION METHOD
        INTEGER CEMETH
C PHASE NUMBERS FOR MOB AND FOR CLASFY/KTYPE
        INTEGER MOBPHA,KTYPHA,FOBPHA,BANDPH,FOURPH
C RE-RUN FLAGS
        LOGICAL MOBFLG,KTYFLG,ALLFLG,OSFLG
C RANDOM AREAS
        INTEGER SLCL,SLCS,SLID,S,Y,X,SL1,SL2
```

```
      INTEGER SPAR(10),SST(513),NST(513),S1,S2
      INTEGER KEY(37)
      BYTE LABEL(73),BLACK(72),PARBUF(80),MOBB(568)
C
C  CLASSFICIATION TABLES
C
      INTEGER GID(10),SID(90),ISR(6),OFS(91),SCLT(5),SCS(90)
C
C  DATA STATEMENTS
C
      DATA BLKNO/1/,DIRNL/2/,DIRNS/3/,LENGTH/4/,IOD/5/,CIL/6/,CID/7/
     1,CIA/8/,CENLIN/9/,PERIM/10/,AREA/11/,PSQDA/12/,CEMETH/13/
      DATA MAXPAR/500/,FOSPHA/6/,MOBPHA/8/,KTYPHA/9/,BANDPH/14/
      DATA DEGPRD/57.2958/,FOURPH/15/
      DATA LABEL/73*' '/,BLACK/72*127/
      DATA NKEY/37/
      DATA MOBFLG/.FALSE./,KTYFLG/.FALSE./,ALLFLG/.FALSE./,OSFLG/.FALSE./
      CALL MVL('ARLWU D BCALSKNNMAKCFENXDEP SPMXIRIGMCDSRF
     1A X C F R M S LDMWMDL H WAAXRBQB',KEY,74)
C
C  INITIALIZE CHROMOSOME DATA SET
      CALL TYPE(' CHECK KARYOTYPE ',0)
      CALL RCA
C  READ CURSOR ADJUSTMENTS
      CALL AFILE(IOBUF,1,'RCR       ',*13,*13)
      CALL OPEN(IOBUF,1024,1,1,'RCR')
      CALL GLABEL(IOBUF,SPAR,IB)
      CALL MVL(IOBUF(IB+1+72),LABEL(2),72)
C
C  READ IN DIRECTORY AND CLASSIFICATION TABLES
C
      CALL GET(IOBUF,1,IB)
      CALL MVL(IOBUF(IB+1),NOB,18)
      CALL MVL(IOBUF(IB+31),CHDIR(1,1),2*15*30)
      CALL GET(IOBUF,2,IB)
      CALL MVL(IOBUF(IB+31),CHDIR(1,31),2*15*30)
      CALL GET(IOBUF,3,IB)
      CALL MVL(IOBUF(IB+1),NSO,2*294)
C
C  READ PREVIOS PARAMETERS
C
      CALL RPARAM(M,MOBPAR,MAXPAR,MOBPHA)
      CALL RPARAM(K,KTYPAR,MAXPAR,KTYPHA)
      IF(K.LT.92) GOTO 65
      K=K-92
      OSFLG=.TRUE.
C  DO NOT RECLASSIFY IF OFS PARAMETERS ARE PRESENT
C  ERASE OLD OFS PARAMETERS, IF PRESENT
C
65    IF(M.EQ.0) GOTO 100
      DO 70 I=1,M
      IF(MOBPAR(I).EQ.'SE') GOTO 75
70    CONTINUE
      GOTO 100
C  REMOVE OLD SE PARAMETERS
75    M=I-1
C  REQUEST OPERATOR INTERACTION
C
100   CONTINUE
110   CALL PARAM(NP,PAR,100,PARBUF)
      IF(NP.EQ.0) GO TO 500
      IP=1
C
C  DECODE PARAMETERS
C
      DO 200 J=1,NKEY
      IF(PAR(IP).EQ.KEY(J)) GOTO (1000,1050,900,910,950,1250,1300,1350
     1,1450,1500,1550,1600,1650,1700,1800,1850,1950,2000,2050,2125,2150
     2 2200,2250,1100,1150,1200,1750,2100,1050,1050,1050,2300,3
     3,2350,2400,2450,2500),J
200   CONTINUE
      CALL TYPE(' PARAMETER ERROR')
      CALL TYPE('0')
      GO TO 100
```

```
250     CALL TYPE(' CURSOR ERROR')
        CALL TYPE('0')
        GOTO 100
3       CALL TYPE(' TYPE ONE OF THE FOLLOWING KEYWORDS TO SELECT AN OPTION')
        CALL TYPE(' C - CHANGE CENTROMERE (USE CURSOR)')
        CALL TYPE(' F - FLIP AND CHANGE CENTROMERE (USE CURSOR)')
        CALL TYPE(' R - ROTATE CHROMOSOME (USE CURSOR)')
        CALL TYPE(' M - MOVE CHROMOSOME TO ANOTHER SLOT')
        CALL TYPE(' X - REMOVE CHROMOSOME FROM KARYOTYPE')
        CALL TYPE(' P - PUSH A GROUP OF CHROMOSOMES RIGHT OR LEFT')
        CALL TYPE(' L - ADD A LABEL (TYPE LABEL ON SAME LINE)')
        CALL TYPE(' A - ABORT')
        CALL TYPE(' S - SET UP CURSOR TO CORRECT FOR DRIFT')
        CALL TYPE(' U OR D - MOVE CURSOR UP OR DOWN')
        CALL TYPE(' RF - RERUN FOB')
        CALL TYPE(' DS - DISPLAY SPREAD')
        CALL TYPE(' BC - CALL THE BANDED CLASSIFIER')
        CALL TYPE(' RB - RERUN THE BANDED CLASSIFIER')
        CALL TYPE(' QB - QUICK BAND CALCULATION')
        CALL TYPE(' WA - DISPLAY WAVEFORMS')
        CALL TYPE(' AX - DISPLAY AXES')
        CALL TYPE(' KC - CLEAR CLASFY PARAMETERS')
        CALL TYPE(' MC - CLEAR MOB PARAMETERS')
        CALL TYPE(' MA OR FE - MALE OR FEMALE')
        CALL TYPE(' NX - NO X SEPARATION FROM C GROUP')
        CALL TYPE(' IF KARYOTYPE IS OK, TYPE CARRIAGE RETURN')
        CALL TYPE('0')
        GOTO 100
C
C PARAMETER U OR D - MOVE CURSOR UP OR DOWN
C
900     CALL MCU
        GOTO 110
910     CALL MCD
        GOTO 110
C
C PARAMETER BC - CALL BANDED CLASSIFIER
C
950     CALL APHASE(BANDPH)
        GOTO 700
C
C PARAMETER AR - SET MAXIMUM AND MINIMUM AREAS OF VALID CHROMOSOMES
C
1000    CALL MVL(PAR(IP),MOBPAR(M+1),8)
        M=M+4
        MOBFLG=.TRUE.
        GO TO 110
C
C PARAMETER LW - LOCATE CENTROMERE BY WIDTY RATHER THAN DENSITY
C
1050    CALL MVL(PAR(IP),MOBPAR(M+1),4)
        M=M+2
        MOBFLG=.TRUE.
        GO TO 110
C
C PARAMETER CI - SET CENTROMERE OF CHROMOSOEM SPECDIFIED TO THAT
C INDICATED BY CURSOR POSITION
C
1100    CALL KURSOR(Y,X,L,S,SLID,SLCL,SLCS,N)
        IF(N.EQ.0) GOTO 250
        SEL(N)=.TRUE.
        CALL MVL('CI',MOBPAR(M+1),2)
        MOBPAR(M+3)=N
        INL=CHDIR(DIRHL,N)
        MOBPAR(M+4)=L-(SLCL-INL/2)+1
        CALL DLINE(BLACK,Y,X,4,1,-1)
        CALL DLINE(BLACK,Y,X,4,1,-1)
        IF(MOBPAR(M+4).GE.INL.OR.MOBPAR(M+4).LE.1) GOTO 250
        M=M+4
        MOBFLG=.TRUE.
        GO TO 110
C
C PARAMETER FL - FLIP SPECIDFIED CHROMOSOEM AND SET CENTROMERE
C
1150    CALL KURSOR(Y,X,L,S,SLID,SLCL,SLCS,N)
```

```
      IF(N.EQ.0) GOTO 250
      SEL(N)=.TRUE.
      CALL MVL('FL',MOBPAR(M+1),2)
      MOBPAR(M+3)=N
      INL=CHDIR(DIRNL,N)
      MOBPAR(M+4)=L-(SLCL-INL/2)+1
      CALL DLINE(BLACK,Y,X,4,1,-1)
      CALL DLINE(BLACK,Y,X,4,1,-1)
      IF(MOBPAR(M+4).GE.INL.OR.MOBPAR(M+4).LE.1) GOTO 250
      M=M+4
      MOBFLG=.TRUE.
      GO TO 110
C
C PARAMETER RO - ROTATE INDICATED CHROMOSOME SO THAT THE 2 CURSOR
C SPTS BECOME VERTICAL
C
1200  CALL KURSOR(Y,X,L,S,SLID,SLCL,SLCS,N)
      IF(N.EQ.0) GOTO 250
      CALL DLINE(BLACK,Y,X-2,3,1,-1)
      CALL DLINE(BLACK,Y,X-2,3,1,-1)
      SEL(N)=.TRUE.
      CALL MVL('RO',MOBPAR(M+1),2)
      MOBPAR(M+3)=N
      FRSTY=Y
      FRSTX=X
      CALL TYPE('+MOVE CURSOR TO END OF AXIS',0)
      CALL PARAM(NP,PAR,100)
      CALL KURSOR(Y,X,L,S,SLID,SLCL,SLCS,N)
      CALL DLINE(BLACK,Y,X-2,3,1,-1)
      CALL DLINE(BLACK,Y,X-2,3,1,-1)
      SY=Y
      SX=X
      IF(FRSTX.EQ.SX) GO TO 1217
      IF(FRSTY.LE.Y) GO TO 1210
      SY=FRSTY
      SX=FRSTX
      FRSTY=Y
      FRSTX=X
1210  THETA=ATAN2((SX-FRSTX),(SY-FRSTY))
      GO TO 1215
1217  THETA=0.
1215  CONTINUE
      MOBPAR(M+4)=THETA*DEGPRD
      M=M+4
      MOBFLG=.TRUE.
      GOTO 110
C
C PARAMETER AL - RE-MOB ALL CHROMOSOMES
C
1250  ALLFLG=.TRUE.
      GO TO 110
C
C PARAMETER SK - OUTPUT SKELETON PICTURES INSTEAD OF GREY LEVEL PICTURE
C
1300  MOBPAR(M+1)=PAR(IP)
      M=M+2
      MOBFLG=.TRUE.
      GO TO 110
C
C PARAMETER NN - NO OBJECT NUMBERS
C
1350  KTYPAR(K+1)=PAR(IP)
      K=K+2
      KTYFLG=.TRUE.
      GO TO 110
C
C PARAMETER MA - MALE KARYOTYPE
C
1450  KTYPAR(K+1)=PAR(IP)
      K=K+2
      KTYFLG=.TRUE.
      GO TO 110
C
C PARAMETER KC - CLEAR CLASFY/KTYPE PARAMETERS
C
1500  K=0
```

```
      CALL WPARAM(K,KTYPAR,KTYPMA)
      OSFLG=.FALSE.
      KTYFLG=.TRUE.
      GO TO 110
C
C PARAMETER FE - FEMALE KARYOTYPE
C
1550  KTYPAR(K+1)=PAR(IP)
      K=K+2
      KTYFLG=.TRUE.
      GO TO 110
C
C PARAMETER NX - NO X SEPARATION FROM C GROUP
C
1600  KTYPAR(K+1)=PAR(IP)
      K=K+2
      KTYFLG=.TRUE.
      GO TO 110
C
C PARAMETER DE DEBUG OPTION OH
C
1650  KTYPAR(K+1)=PAR(IP)
      K=K+2
      KTYFLG=.TRUE.
      GO TO 110
C
C PARAMETER P - PUSH A GROUP OF CHROMOSOMES RIGHT OR LEFT
C
1700  CALL KURSOR(Y,X,L1,S1,SL1,SLCL,SLCS,N)
      CALL TYPE('+MOVE CURSOR TO END OF PUSH ',0)
      CALL PARAM(NP,PAR,100)
      CALL KURSOR(Y,X,L2,S2,SL2,SLCL,SLCS,N)
      IF(S1.LT.S2) GOTO 1725
C GOTO 1725 FOR PUSH TO THE RIGHT
C
C PUSH LEFT
      NSL=SL1-SL2+1
      IF(NSL.LT.2.OR.NSL.GT.18) GOTO 250
      Y=2*(L1-1)
      CALL DLINE(127,Y,2*S2,S1-S2,1,-1)
      X=2*(S2-1)
      DO 1710 I=2,12,2
      CALL DLINE(BLACK,Y+I-14,X+14-I,2,1,-1)
1710  CALL DLINE(BLACK,Y+I,X+I,2,1,-1)
      CALL MVW(OFS(SL2),PAR,NSL)
C SAVE OFS IN PAR
      CALL MVW(PAR(2),OFS(SL2),NSL-1)
      OFS(SL1)=PAR(1)
      GOTO 1776
C PUSH RIGHT   S1 LT S2
1725  Y=2*(L1-1)
      NSL=SL2-SL1+1
      IF(NSL.LT.2.OR.NSL.GT.18) GOTO 250
      CALL DLINE(127,Y,2*S1,S2-S1,1,-1)
      X=2*S2
      DO 1730 I=2,12,2
      CALL DLINE(BLACK,Y+I-14,X+I-14,2,1,-1)
1730  CALL DLINE(BLACK,Y+I,X-I,2,1,-1)
      CALL MVW(OFS(SL1),PAR,NSL)
      CALL MVW(PAR(1),OFS(SL1+1),NSL-1)
      OFS(SL1)=PAR(NSL)
      GOTO 1776
C
C PARAMETER MV - MOVE INDICATED CHROMSOME TO SLOT SHOWN BY CURSOR
C
1750  CALL KURSOR(Y,X,L1,S1,SLID,SLCL,SLCS,N)
      CALL DLINE(BLACK,Y,X-2,3,1,-1)
      SVSLID=SLID
      CALL TYPE('+MOVE CURSOR TO OTHER SLOT ',0)
      CALL PARAM(NP,PAR,100)
      CALL KURSOR(Y,X,L2,S2,SLID,SLCL,SLCS,N)
      CALL ADL(L1,S1,L2,S2,SST,NST,512,512)
      DO 1770 L=L1,L2
      Y=2*(L-1)
```

```
        X=2*(SST(L)-1)
1770    CALL DLINE(127,Y,X,NST(L),1,-1)
        SVID=OFS(SLID)
        OFS(SLID)=OFS(SVSLID)
        OFS(SVSLID)=SVID
1775    OSFLG=.TRUE.
        KTYFLG=.TRUE.
        GO TO 110
C
C PARAMETER SP - SET SKELETON PARAMETERS
C
1800    CALL MVL(PAR(IP),MOBPAR(M+1),8)
        K=K+4
        MOBFLG=.TRUE.
        GO TO 110
C
C PARAMETER MX - SET MAXIMUM # OF CHROMOSOEMS PRE GROUP
C
1850    CALL MVL(PAR(IP),KTYPAR(K+1),24)
        K=K+12
        KTYFLG=.TRUE.
        GO TO 110
C
C PARAMETER IR - SET INITIAL SLOT FOR EACH ROW
C
1950    CALL MVL(PAR(IP),KTYPAR(K+1),14)
        K=K+7
        KTYFLG=.TRUE.
        GO TO 110
C
C PARAMETER IG - SET INITIAL SLOT FOR EACH GROUP
C
2000    CALL MVL(PAR(IP),KTYPAR(K+1),28)
        K=K+14
        KTYFLG=.TRUE.
        GO TO 110
C
C PARAMETER MC - CLEAR MOB PARAMETERS
C
2050    M=0
        MOBFLG=.TRUE.
        GO TO 110
C
C PARAMETER SC - SET UP THE CURSOR
2100    CALL SC
        GOTO 110
C SETUP THE CURSOR
C
C PARAMETER DS - DISPLAY SPREAD
C
2125    CALL APHASE(FOBPHA)
        GOTO 700
C
C PARAMETER RF - RERUN FOB
C
2150    CALL APHASE(FOBPHA)
        CALL WPARAM(0,MOBPAR,MOBPHA)
        CALL WPARAM(0,KTYPAR,KTYPHA)
        GOTO 700
C RERUN FOB
C
C PARAMETER AB - ABORT
C
2200    CALL APHASE(0)
        GOTO 700
C
C PARAMETER X - REMOVE OBJECT FROM KARYOTYPE
C
2250    CALL KURSOR(Y,X,L1,S1,SLID,SLCL,SLCS,N)
        DO 2260 I=2,26,2
        CALL DLINE(BLACK,Y+I-14,X+I-16,2,1,-1)
        CALL DLINE(BLACK,Y+I-14,X+14-I,2,1,-1)
2260    CONTINUE
C DRAW AN X OVER THE OBJECT TO BE DELETED
        OFS(SLID)=0
```

```
      OSFLG=.TRUE.
      KTYFLG=.TRUE.
      GOTO 110
C
C PARAMETER L - ADD A LABEL TO INDICATE DIAGNOSIS
C
2300  DO 2310 I=4,72
      IF(IV(PARBUF(I)).EQ.'15) GOTO 2320
2310  CONTINUE
      CALL TYPE(' INCORRECT LABEL FORMAT')
      GOTO 100
2320  LABLEN=I-3
      CALL AFILE(NOBB,1,'PIC      ',5,5)
      CALL OPEN(NOBB,512,0,2,'NOB')
      CALL GET(NOBB,1,IN)
      CALL PUT(NOBB,I,IN)
      CALL MVL(PARBUF(3),NOBB(IN+290),LABLEN)
      CALL CLOSE(NOBB)
C ALSO ADD TO THE NOB OUTPUT LABEL FOR RESEL'S BENEFIT
      CALL GLABEL(IOBUF,SPAR,IB)
      CALL MVL(PARBUF(3),IOBUF(IB+290),LABLEN)
      CALL PLABEL(IOBUF,SPAR,IOBUF(IB+1))
      GOTO 110
C
C PARAMETER WAVE - DISPLAY WAVEFORMS FROM BAND
2350  CALL UPARAM(2,'WAVE',BANDPH)
      GOTO 950
C
C PARAMETER AXIS - DISPLAY AXES FROM BAND
C
2400  CALL UPARAM(2,'AXIS',BANDPH)
      GOTO 950
C
C PARAMETER RB - RERUN BANDED CLASSIFIER
C
2450  CALL APHASE(FOURPH)
      GOTO 700
C
C PARAMETER QB - QUICK BAND CALCULATION (ONLY THE C GROUP)
C
2500  CALL SSWTCH(7,ISW7)
      IF(ISW7.NE.1) CALL UPARAM(2,'QB   ',BANDPH)
      GOTO 950
C
C DONE LOOKING AT PARAMETERS, SEE IF A RE-RUN IS NECCESSARY
C
500   IF(.NOT.ALLFLG.AND..NOT.KTYFLG.AND..NOT.NOBFLG) GO TO 700
      IF(.NOT.OSFLG) GOTO 550
C
C WRITE THE OFS PARAMETERS FOR CLASFY
C
      CALL MVL('OS',KTYPAR(K+1),2)
      CALL MVU(OFS,KTYPAR(K+3),90)
      K=K+92
550   CONTINUE
      IF(.NOT.ALLFLG.AND..NOT.NOBFLG) GO TO 650
      IF(ALLFLG) GO TO 610
C
C MUST RE-RUN NOB ON SELECTED CHROMOSOMES
C
      CALL MVL('SE',NOBPAR(M+1),2)
      M=M+3
      MM=M
      NM=0
      DO 600 N=1,NOB
      IF(.NOT.SEL(N)) GO TO 600
      M=M+1
      NM=NM+1
      NOBPAR(M)=N
600   CONTINUE
      IF(NM.EQ.0) GO TO 605
      NOBPAR(MM)=NM
      CALL PUT(IOBUF,1,IB)
      CALL MVL(NOB,IOBUF(IB+1),18)
      CALL MVL(CHDIR(1,1),IOBUF(IB+31),2*15*30)
```

```
      CALL PUT(IOSUF,2,IB)
      CALL MVL(CHDIR(1,31),IOBUF(IB+31),2*15*30)
      GO TO 610
605   M=M-3
C
C SELECT MOB AS NEXT PHASE TO BE RUN
C
610   CALL APHASE(MOBPHA)
      CALL UPARAM(M,MOBPAR,MOBPHA)
      CALL UPARAM(K,KTYPAR,KTYPHA)
      GO TO 700
C
C SELECT CLASFY AS NEXT PHASE TO BE RUN
C
650   CALL APHASE(KTYPHA)
      CALL UPARAM(K,KTYPAR,KTYPHA)
700   CONTINUE
      CALL CLOSE(IOBUF)
      CALL EXIT
      END



      SUBROUTINE RESEL
C     RESEL IS USED TO ENTER INFORMATION ON MEASURED CHROMO
C     SOMES INTO KROMDATA. THE INPUT IS FROM MOB OUTPUT.
C
      IMPLICIT INTEGER(A-Z)
      COMMON/C1/ MBUF,KBUF,NEXT,NUSED,PID,RECS,ON,ONL,ONS,
      1OLEN,OIOD,OAREA,OCIL,OCID,OCIA,OFS
      REAL*8 DID(3)
      REAL*4 CFOUR(60,8),PHI(60,8),MU(18,24),SIGMA(18,24)
      REAL*4 ISUM,ASUM,ALSUM,LEN,CI,NCC,SUMXY,OCFOUR(51,8),OPHI(51,7)
      INTEGER NFD(10,3),CSPAR(5),PID(425),RECS(85)
      BYTE ON(80),ONL(80),ONS(80),OLEN(80),OCIL(80),OCID(80),OCIA(80)
      BYTE PBUF(560),LABEL(124),C(3640),OBDATA(3072)
      BYTE MBUF(2104),KBUF(56),FMSG(40),TMSG(23),GMSG(128)
      INTEGER PSPAR(10)
      INTEGER SPAR(10),KSPAR(10),OIOD(80),OAREA(80),OFS(90),
      2TFS(90),SCANDT(9),TN(90),NN(60),GFS(90),NFD(10)
      EQUIVALENCE (OBDATA,OCFOUR),(OBDATA(1633),OPHI)
      EQUIVALENCE (C(57),MU),(C(1785),SIGMA)
      EQUIVALENCE (SPAR(6),SCODE),(NLP,PSPAR(1))
      DATA ND/3/,DID/'46XX    ','46XY    ','45X0    '/
      DATA NFD/6,4,16,6,6,4,4,0,0,0,6,4,15,6,6,4,5,0,0,0,
      1 6,4,15,6,6,4,4,0,0,0/
      DATA GMSG/128*' '/
      DATA TFS/1,1,40,40,2,2,40,40,3,3,40,40,4,4,5,5,40,40
      2,6,6,7,7,8,8,9,9,10,10,11,11,12,12,23,23,40,40
      3,13,13,14,14,15,15,40,40,16,16,40,40,17,17,18,18,40,40
      4,19,19,20,23,40,40,26,26,25,25,21,21,22,22,24,24,40,40
      5,18*40/
      DATA GFS/12*1,6*2,18*3,8*4,10*5,6*6,2*8,10*7,8*8,10*9/
      DATA CMT/61/
C CURRENT MISCELLANEOUS INDEX = 61
C
C     OPEN MOB OUTPUT AND COPY NECESSARY DATA FROM MOB LABEL
C
      CALL SSWTCH(10,ISW10)
      IF(ISW10.NE.1) CALL APHASE(19)
C IF SW10 IS DOWN SET TO CALL ABNORM
      CALL AFILE(MBUF,1,'RCR     ',,*13,*13)
      CALL OPEN(MBUF,1024,1,0,'RCR')
      CALL GLABEL(MBUF,SPAR,NL)
      CALL MVW(MBUF(ML+13),SCODE,1)
      CODE=SCODE
      IF(SCODE.LT.0) SCODE=-SCODE
      IF(SCODE.GT.0.AND.SCODE.LE.15) GOTO 5
C CHECK FOR VALID CODE
      CALL CLOSE(MBUF)
      RETURN
5     CONTINUE
      CALL MVL(MBUF(ML+73),GMSG(1),64)
      CALL MVL(MBUF(ML+290),GMSG(107),22)
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      CALL MVL(MBUF(ML+73),LABEL,64)
      CALL MVL(MBUF(ML+145),LABEL(65),20)
      CALL MVL(MBUF(ML+217),LABEL(85),20)
      CALL MVL(MBUF(ML+289),LABEL(105),20)
C SAVE LABEL INFORMATION
C
C     OPEN KROMDATA AND GET NL
C
      CALL AFILE(KBUF,4,'KDATA     ',6,6)
      IF(CODE.LT.0) CALL AFILE(KBUF,4,'BDATA     ',6,6)
      CALL OPEN(KBUF,1024,0,2,'KRM')
      CALL GLABEL(KBUF,KSPAR,KL)
      NL=KSPAR(1)
C
C READ SOURCE DIRECTORY RECORD
C
10    CALL GET(KBUF,SCODE,KD)
      IF(NUSED.LT.95) GOTO 22
C IF SPACE IN THIS RECORD GOTO 85
      IF(NEXT.EQ.0) GOTO 20
C IF LAST DIRECTORY RECORD GO MAKE A NEW ONE
      SCODE=NEXT
      GOTO 10
C GO READ NEXT DIRECTORY RECORD
20    NL=NL+1
      NEXT=NL
C STORE NEXT RECORD IN THIS DIRECTORY RECORD
      CALL PUT(KBUF,SCODE,KD)
      CALL GET(KBUF,NL,KD)
      SCODE=NL
      NUSED=0
22    CONTINUE
      DO 24 I=1,421,5
      IF(PID(I).EQ.0) GOTO 26
C IF THIS SLOT IS FREE GOTO 26
24    CONTINUE
      CALL TYPE(' RESEL ERROR')
      CALL TYPE('0')
      PAUSE 12345
26    CALL MVL(LABEL(21),PID(I),10)
C STORE PATIENT ID
      NUSED=NUSED+1
      IR=(I+4)/5
      REC=RECS(IR)
      IF(REC.NE.0) GOTO 28
C GOTO 28 IF THIS RECORD WAS DELETED
      NL=NL+1
C NEED TO MAKE A NEW RECORD
      REC=NL
      RECS(IR)=REC
      IF(CODE.LT.0) NL=NL+3
C ADD 3 MORE IF BANDED
28    CALL PUT(KBUF,SCODE,KD)
      CALL GLABEL(KBUF,KSPAR,KL)
      KSPAR(1)=NL
C UPDATE NL
      CALL PLABEL(KBUF,KSPAR,KBUF(KL+1))
C
C     GET MOB OUTPUT DATA AND TRANSFER TO KROMDATA
C
C
C     GET OFS FROM MOB OUTPUT AND CONVERT TO TYPE
C
      CALL GET(MBUF,3,MD)
      II=MD+215
      DO 30 I=1,90
      II=II+2
30    CALL MVW(MBUF(II),OFS(I),1)
      CALL ZIA(ON,40)
      CALL ZIA(NN,60)
      CALL ZIA(TN,90)
      CALL ZIA(MFG,10)
      DO 40 J=1,90
      IF(OFS(J).EQ.0) GOTO 40
      G=OFS(J)
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      NFG(G)=NFG(G)+1
      TN(OFS(J))=TFS(J)
   40 CONTINUE
C
C     MOVE NECESSARY DATA FROM MOB LABEL AND LINE 1 TO KBUF
C
      CALL GET(MBUF,1,MD)
      CALL PUT(KBUF,REC,KD)
      CALL MVW(LABEL,KBUF(KD+1),62)
      CALL MVW(MBUF(MD+1),NOB,1)
C
      N=1
   50 IF(TN(N).EQ.0) GOTO 80
C
C     GOTO 80 IF THIS OBJECT IS NOT TO BE ENTER
C
      T=2*TN(N)-1
      IF(T.LT.60.AND.T.GT.0) GOTO 60
      T=CMT
      IF(T.GT.80) GOTO 80
C USE NEXT AVAILABLE SPACE IN MISCELLANEOUS AREA
      CMT=CMT+1
   60 CONTINUE
      IF(ON(T).EQ.0) GOTO 70
C
C     GOTO 70 IF FIRST SLOT FOR THIS TYPE IS EMPTY
      T=T+1
   70 ON(T)=N
      NN(N)=T
   80 CONTINUE
      N=N+1
      IF(N.LE.NOB) GOTO 50
C
C     TRANSFER CHDIR. 30 BYTES IS OFFSET OF ONL ON MBUF
C
      II=30+MD
      IST=1
      IEND=30
      DO 100 J=1,2
      K=0
      DO 90 I=IST,IEND
      K=K+1
      NNI=NN(I)
      IF(NNI.EQ.0) GOTO 90
      IM=(K-1)*30+II
      CALL MVL(MBUF(IM+3),ONL(NNI),1)
      CALL MVL(MBUF(IM+5),ON3(NNI),1)
      CALL MVL(MBUF(IM+7),OLEN(NNI),1)
      CSUM=CSUM+1
      LSUM=LSUM+OLEN(NNI)
      CALL MVW(MBUF(IM+9),OIOD(NNI),1)
      ISUM=ISUM+OIOD(NNI)
      CALL MVW(MBUF(IM+21),OAREA(NNI),1)
      ASUM=ASUM+OAREA(NNI)
      CALL MVL(MBUF(IM+11),OCIL(NNI),1)
      CALL MVL(MBUF(IM+13),OCID(NNI),1)
      CALL MVL(MBUF(IM+15),OCIA(NNI),1)
   90 CONTINUE
      IF(J.EQ.2) GOTO 100
      CALL GET(MBUF,2,MD)
      IST=31
      IEND=NOB
      II=30+MD
  100 CONTINUE
      CALL MVW(CSUM,KBUF(KD+125),1)
      CALL MVW(LSUM,KBUF(KD+127),1)
      CALL MVW(ISUM,KBUF(KD+129),2)
      CALL MVW(ASUM,KBUF(KD+133),2)
      IF(CODE.GT.0) GOTO 190
C
C CONTROL SPREAD PROCESSING
C
      CALL GET(MBUF,4,IM)
      CALL MVW(MBUF(IM+1),CFOUR(1,1),480)
      CALL GET(MBUF,5,IM)
```

```
          CALL MVW(MBUF(IM+1),CFOUR(1,5),480)
          CALL GET(MBUF,6,IM)
          CALL MVW(MBUF(IM+1),PHI(1,1),480)
          CALL GET(MBUF,7,IM)
          CALL MVW(MBUF(IM+1),PHI(1,5),480)
          DO 110 N=1,NOB
          T=NN(N)
          IF(T.EQ.0.OR.T.GT.51) GOTO 110
C GET THE FOURIER DATA
          DO 102 I=1,8
102       OCFOUR(T,I)=CFOUR(N,I)
          DO 104 I=1,7
104       OPHI(T,I)=PHI(N,I+1)
110       CONTINUE
190       CONTINUE
C
C         WRITE RECORD ON KROMDATA
C
          CALL MVW(ON,KBUF(KD+145),440)
          NC=0
          DO 200 G=1,9
          CALL OUTCON(NFG(G),GMSG(68+G*4),4)
200       NC=NC+NFG(G)
          CALL OUTCON(NC,GMSG(68),4)
          IF(IV(GMSG(107)).NE.32) GOTO 225
C IF OPERATOR SUPPLIED A DIAGNOSIS GOTO 230
          DO 220 N=1,ND
          DO 210 G=1,10
          IF(NFG(G).NE.NFD(G,N)) GOTO 220
210       CONTINUE
C NFG MATCHES THIS DIAGNOSIS
          GOTO 230
220       CONTINUE
C NO MATCH
225       N=0
          GOTO 250
230       CALL MVL(DID(N),GMSG(107),8)
          CALL MVL(DID(N),KBUF(KD+106),8)
250       CALL AFILE(PBUF,1,'PIC       ',5,5)
          CALL OPEN(PBUF,512,0,2,'NOB')
          CALL GET(PBUF,1,IP)
          CALL OUTCON(REC,PBUF(IP+176),4)
          CALL MVL('RECORD',PBUF(IP+166),6)
C STORE RECORD NUMBER IN NOB OUTPUT FOR HCOPY
          IF(N.NE.0) CALL MVL(DID(N),PBUF(IP+290),8)
          CALL PUT(PBUF,1,IP)
          CALL CLOSE(PBUF)
C STORE DIAGNOSIS N IN PREP AND NOB OUTPUT FOR HCOPY
          CALL MVL(' ** XXXXXXXXXX ON RECORD XXXX  ',FMSG,31)
          CALL MVL(LABEL(21),FMSG(5),10)
          CALL OUTCON(REC,FMSG(29),4)
          CALL MVL(GMSG(107),FMSG(32),8)
          CALL TYPE(FMSG)
          IF(CODE.GT.0) GOTO 300
C WRITE THE BANDED RECORDS
          DO 270 I=1,3
          CALL PUT(KBUF,REC+I,IK)
          CALL MVW(OBDATA(I*1024-1023),KBUF(IK+1),512)
270       CONTINUE
300       CONTINUE
C WRITE PATIENT REPORT RECORD
          CALL AFILE(PBUF,4,'PDATA     ',6,6)
          CALL OPEN(PBUF,512,0,2,'PRP')
          CALL GLABEL(PBUF,PSPAR,IP)
          NLP=NLP+1
          CALL PLABEL(PBUF,PSPAR,PBUF(IP+1))
          CALL GET(PBUF,NLP,IP)
          CALL MVL(GMSG,PBUF(IP+1),128)
          CALL PUT(PBUF,NLP,IP)
          CALL CLOSE(PBUF)
          CALL CLOSE(KBUF)
          CALL CLOSE(MBUF)
          CALL TYPE('0')
          RETURN
          END
```

```
C       MASK2 - COMBINE 2 PICTURES AND ADD A BORDER
C       CALMS VERSION
        SUBROUTINE MASK2(DUNIT,FILPEX)
        IMPLICIT INTEGER(A-Z)
        REAL STATS(256)
        BYTE A(6203),B(6200),C(992),LE(12),RE(12)
        COMMON STATS,LE,C,RE
        INTEGER*2 LOW(512),HIGH(511)
        EQUIVALENCE (LOW,STATS),(HIGH(1),LOW(2))
        INTEGER*2 SPAR(5),SPARB(5),PAR(10),KEY(3)
        BYTE FILPEX(12)
        DATA MAXNS/992/
        DATA NKEY/3/,KEY/'HI','NS','KG'/,HFLAG/0/,NFR/128/,ISIZE/100/
        CALL AFILE(A,1,'PIC      ',5,5)
C ASSIGN DK1:PIC[5,5] AS DEFAULT FILE FOR NOB OUTPUT
        CALL OPEN(A,3072,1,0,'NOB')
        CALL GLABEL(A,SPAR,IA)
        CALL AFILE(B,5,'PIC      ',5,5)
C ASSIGN DK5:PIC[5,5] AS DEFAULT FILE FOR KGM
1       CALL RPARAM(NP,PAR,10)
11111   IP=1
3       IF(IP.GT.NP) GOTO 30
        DO 5 J=1,NKEY
        IF(PAR(IP).EQ.KEY(J)) GOTO (10,12,15),J
5       CONTINUE
8       CALL TYPE(' ** PARAMETER ERROR')
        CALL TYPE('0')
        PAUSE
10      HFLAG=1
        CALL ZIA(STATS,512)
        IP=IP+2
        GOTO 3
12      ISIZE=PAR(IP+2)
        IP=IP+1
        GOTO 10
15      CALL AFILE(B,PAR(IP+2),PAR(IP+3),2,2)
C ASSIGN A DIFFERENT KGM FILE
30      CONTINUE
        CALL OPEN(B,3072,1,0,'KGM')
        CALL GLABEL(B,SPARB,IB)
        NL=SPAR(1)
        IF(SPARB(1).GT.NL) NL=SPARB(1)
        NS=SPAR(2)+SPARB(2)+1
        IF(NS.GT.MAXNS) NS=MAXNS
        IF(SPAR(3).NE.7) NFR=256
        CALL MSUB(A(IA+1),NS,DUNIT,FILPEX)
C LABEL CALL TO MSUB
        DO 100 L=1,NL
        IF(L.GT.SPAR(1)) GOTO 50
        CALL GET(A,L,IA)
        CALL MVL(A(IA+1),C,SPAR(2))
        GOTO 55
50      CALL ITLA(0,C,SPAR(2))
55      C(SPAR(2)+1)=127
        IF(L.GT.SPARB(1)) GOTO 60
        CALL GET(B,L,IB)
        CALL MVL(B(IB+1),C(SPAR(2)+2),SPARB(2))
        GOTO 65
60      CALL ITLA(0,C(SPAR(2)+2),SPARB(2))
65      CALL MSUB(C,NS)
        IF(HFLAG.EQ.1) CALL LSTAT(SPAR(2),A(IA+1),STATS,1,1)
C IF HISTOGRAM WAS REQUESTED, GATHER THE STATISTICS
100     CONTINUE
        IF(HFLAG.EQ.0) GOTO 200
        II=1
C CONVERT THE FREQUENCY COUNTS TO REAL NUMBERS
        DO 120 I=1,NFR
        STATS(I)=LOW(II)+HIGH(II)*32768.
120     II=II+2
        CALL MSUB(STATS,-NFR,ISIZE)
        GOTO 220
200     CALL MSUB(0,0)
220     CONTINUE
        CALL CLOSE(A)
        END
```

```
      SUBROUTINE MSUB(LOC,NSO,ISIZE,FILPEX)
      IMPLICIT INTEGER(A-Z)
      REAL STATS(256),MAXF,HSIZE
      BYTE FILPEX(12),DATA(1000)
      COMMON STATS,DATA
      INTEGER*2 FREQ(256),SPAR(5)
      EQUIVALENCE (FREQ,STATS)
      INTEGER*2 ISIZE(5)
      BYTE DSRN(6258),T(2104),DMSG(28)
      EQUIVALENCE (DSRN(4153),T),(DSRN(6257),ISW5)
      BYTE LAB(512),LOC(976),BUF(1000),LN(4),LOGN(4)
      DATA MAXNS/976/,MINNS/360/
      DATA SPAR/0,0,4,1,512/
      DATA MAXF/1./,HSIZE/200./,L/0/,WHITE/15/,STEP/16/,LBW/0/
      IF(LBW.GT.0) GOTO 100
C GOTO 100 IF NOT INITIAL CALL
      CALL AFILE(DSRN,ISIZE,FILPEX,2,2)
      CALL SSWTCH(5,ISW5)
      BUFSIZ=3072
      IF(ISW5.EQ.1) BUFSIZ=2048
C IF TAPE OUTPUT, DECREASE SIZE OF DSRN TO MAKE ROOM
      CALL OPEN(DSRN,BUFSIZ,1,1,'MSK')
      CALL MVW(LOC,LAB,256)
      CALL LTI(LAB(7),BPE)
C SAVE LABEL AND BPE
      NS=NSO
      IF(NS.GT.MAXNS) NS=MAXNS
      NSD2=(NS+1)/2
C NSD2 IS THE NUMBER OF WORDS TO MOVE TO DATA
      IF(NS.LT.MINNS) NS=MINNS
C MINNS IS THE MINIMUM SIZE FOR THE DATE AND TIME LABEL AND HSTGRM
      NSW=NS+24
      NWW=(NSW+1)/2
      SPAR(2)=NWW
      SPAR(4)=512/NWW
      IF(SPAR(4).EQ.0) SPAR(4)=1
      CALL PLABEL(DSRN,SPAR,LAB)
      IF(ISW5.NE.1) GOTO 50
      CALL MVW(1,T(21),1)
      CALL MVW(-52148,T(23),1)
C SET MVB FOR MT0:
      CALL OPEN(T,1024,1,5,'TAP')
      CALL MVW(1,T(51),1)
C BPB=1
      CALL MVW(NSW,T(45),1)
C RECLEN=NSW
      CALL MVW(NSW,T(47),1)
C BLOCKSIZE = NSW
50    CONTINUE
      CALL ZIA(BUF,NWW)
      CALL WLINE(DSRN,LBW,NSW,BUF,84)
C WRITE 4 BLANK LINES
      CMID=13+NS/2
      GWW=NS/32
C GREY WEDGE WIDTH
      B1=CMID-16*GWW-1
      B2=32*GWW+3
      CALL ITLA(255,BUF(B1),B2)
      CALL WLINE(DSRN,LBW,NSW,BUF,81)
      CALL WEDGE(WHITE,STEP,BUF,NS)
      CALL WLINE(DSRN,LBW,NSW,BUF,12)
      CALL WEDGE(255,-STEP,BUF,NS)
      CALL WLINE(DSRN,LBW,NSW,BUF,12)
      CALL ITLA(255,BUF(B1),B2)
      CALL WLINE(DSRN,LBW,NSW,BUF,81)
C WRITE GREY SCALE
      CALL ZIA(BUF,NWW)
      CALL WLINE(DSRN,LBW,NSW,BUF,1)
      DO 80 K=0,6
      IF(K.EQ.3) CALL REF(5,BUF,NSW)
      DO 70 N=100,NS,100
      CALL OUTCON(N,LN(4),4)
   70 CALL TEXT(LN(2),1,K,BUF(N+9),1)
   80 CALL WLINE(DSRN,LBW,NSW,BUF,1)
      CALL REF(25,BUF,NSW)
```

```
      CALL WLINE(DSRN,LBW,NSW,BUF,83)
C WRITE TOP REFERENCE MARKS
      CALL ITLA(255,BUF(5),8)
      CALL ITLA(255,BUF(13+NS),8)
      CALL WLINE(DSRN,LBW,NSW,BUF,81)
        RETURN
100   CONTINUE
      IF(NSO.LE.0) GOTO 200
C IF END OF PICTURE, GOTO 200
      IF(BPE.NE.7) GOTO 110
      CALL MVW78(LOC,DATA(13),NSD2)
      GOTO 115
110   CALL MVW(LOC,DATA(13),NSD2)
115   L=L+1
C STEP INPUT LINE NUMBER
      CALL ITLA(0,DATA(1),12)
      CALL ITLA(0,DATA(13+NS),12)
C ZERO LINE REFERENCE MARKS
      LP3=L+3
      ML=MOD(LP3,100)
      IF(ML.GT.6.OR.L.LT.4) GOTO 130
C TIME FOR NUMBER OF HUNDREDS
      CALL OUTCON(LP3,LN(4),4)
      CALL TEXT(LN(2),1,ML,DATA(2),1)
      CALL TEXT(LN(2),1,ML,DATA(17+NS),1)
      GOTO 140
  130 CONTINUE
      IF(MOD(L,5).NE.0) GOTO 150
      CALL ITLA(255,DATA(5),4)
      CALL ITLA(255,DATA(17+NS),4)
C INSERT EVERY 5 MARK
  140 CONTINUE
      IF(MOD(L,25).NE.0) GOTO 150
      CALL ITLA(255,DATA(9),4)
      CALL ITLA(255,DATA(13+NS),4)
  150 CONTINUE
      CALL WLINE(DSRN,LBW,NSW,DATA,1)
C WRITE ONE LINE OF DATA
      RETURN
200   CONTINUE
C FINAL ENTRY, WRITE BOTTOM OF PICTURE
      DO 240 K=1,11
      IF(K.LT.5) CALL REF(25,BUF,NSW)
      IF(K.GE.5.AND.K.LE.8) CALL REF(5,BUF,NSW)
      IF(K.EQ.9) CALL ZIA(BUF,NWW)
      IF(ML.GE.6) GOTO 220
C FINISH UP NUMBER THAT WAS STARTED ON LEFT AND RIGHT SIDE
      ML=ML+1
      CALL TEXT(LN(2),1,ML,BUF(2),1)
      CALL TEXT(LN(2),1,ML,BUF(17+NS),1)
  220 CONTINUE
      IF(K.LT.5) GOTO 240
      DO 230 N=100,NS,100
      CALL OUTCON(N,LOGN(4),4)
  230 CALL TEXT(LOGN(2),1,K-5,BUF(N+9),1)
  240 CALL WLINE(DSRN,LBW,NSW,BUF,1)
C WRITE BOTTOM REFERENCE MARKS
      CALL ZIA(BUF,NWW)
      CALL WLINE(DSRN,LBW,NSW,BUF,1)
      CALL ITLA(255,BUF(81),82)
      CALL WLINE(DSRN,LBW,NSW,BUF,81)
      CALL WEDGE(255,-STEP,BUF,NS)
      CALL WLINE(DSRN,LBW,NSW,BUF,12)
      CALL WEDGE(WHITE,STEP,BUF,NS)
      CALL WLINE(DSRN,LBW,NSW,BUF,12)
      CALL ITLA(255,BUF(81),82)
      CALL WLINE(DSRN,LBW,NSW,BUF,81)
C WRITE GREY SCALE
      MAXCHR=(NS+11)/12
        JMAX=433
      DO 250 J=73,JMAX,72
      IF(IV(LAB(J-1)).NE.67) GOTO 260
C FINISHED WITH LABELS IF NO C IN COLUMN 72
        J1=J+1
C SKIP THE FIRST LABEL CHARACTER WHICH IS ALWAYS BLANK
```

```
C FIND THE LENGTH OF THIS LABEL
      DO 242 I=1,70
        IF(LAB(J+70-I).NE.32) GOTO 243
  242 CONTINUE
C ENTIRE LABEL IS BLANK
      GOTO 250
  243 LABLEN=70-I
  244 CHR=LABLEN
      IF(LABLEN.LE.MAXCHR) GOTO 247
C SPLIT UP LABEL IF IT IS TOO LONG
      DO 245 I=1,20
        IF(LAB(J1+MAXCHR-I).EQ.32) GOTO 246
  245 CONTINUE
C NO BLANK FOUND IN 20 CHARACTERS, MAKE ARBITRARY SPLIT
      I=1
  246 CHR=MAXCHR-I+1
  247 CONTINUE
      CALL ZIA(BUF,NWW)
      CALL WLINE(DSRN,LBW,NSW,BUF,84)
      DO 248 K=0,6
      CALL TEXT(LAB(J1),CHR,K,BUF(13),2)
      CALL WLINE(DSRN,LBW,NSW,BUF,82)
  248 CONTINUE
C WRITE LABELS
      J1=J1+CHR
      LABLEN=LABLEN-CHR
      IF(LABLEN.GT.0) GOTO 244
  250 CONTINUE
  260 CONTINUE
        IF(NSO.EQ.0) GOTO 420
C SKIP HISTOGRAM IF NSO EQ 0
        NFR=-NSO
        HSIZE=ISIZE(1)
      CALL ZIA(BUF,NWW)
      CALL WLINE(DSRN,LBW,NSW,BUF,4)
      NFRM1=NFR-1
      DO 320 I=2,NFRM1
      IF(STATS(I).LE.MAXF) GOTO 320
      MAXF=STATS(I)
  320 CONTINUE
      IF(STATS(1).GT.MAXF) STATS(1)=MAXF
      IF(STATS(NFR).GT.MAXF) STATS(NFR)=MAXF
      DO 330 I=1,NFR
330     FREQ(I)=(STATS(I)/MAXF)*HSIZE+.9999
      BARW=NS/NFR
      HSTART=(NS-BARW*NFR)/2+12
      J=HSIZE
  340 H=HSTART
      DO 350 I=1,NFR
      IF(FREQ(I).NE.J) GOTO 350
C TIME TO STORE BAR FOR THIS DN
      CALL ITLA(255,BUF(H),BARW)
  350 H=H+BARW
      CALL WLINE(DSRN,LBW,NSW,BUF,1)
      J=J-1
      IF(J.GE.0) GOTO 340
C THE FOLLOWING CODE WAS COMMENTED OUT TO MAKE ROOM FOR TAPE OUTPUT
C       DO 370 J=8,64,56
C       CALL ZIA(BUF,NWW)
C       HSTEP=J*BARW
C       HMAX=HSTART+NFR*BARW+1
C       DO 360 H=HSTART,HMAX,HSTEP
C  360  CALL ITLA(255,BUF(H),BARW)
C       CALL WLINE(DSRN,LBW,NSW,BUF,5)
C  370  CONTINUE
C       CALL ZIA(BUF,NWW)
C       CALL WLINE(DSRN,LBW,NSW,BUF,2)
C       HSTEP=16*BARW
C       DO 400 K=0,6
C       H=HSTART
C       CALL TEXT('0',1,K,BUF(H-2),1)
C       DO 390 N=16,NFR,16
C       H=H+HSTEP
C       IF(BARW.EQ.1.AND.MOD(N,32).EQ.16) GOTO 390
C       CALL OUTCON(N,LN(4),4)
```

```
C       IF(N.GT.99) GOTO 380
CC N IS 2 CHARACTERS
C         CALL TEXT(LN(3),2,K,BUF(N-5),1)
C         GOTO 390
C  380 CALL TEXT(LN(2),3,K,BUF(N-8),1)
C  390 CONTINUE
C  400 CALL WLINE(DSRN,LBW,NSW,BUF,1)
  420 CONTINUE
        CALL MVL('DD-MMM-YY HH.MM.SS JPL/CALMS',DMSG,28)
        CALL DATE(DMSG)
        CALL TIME(DMSG(11))
      CALL ZIA(BUF,NWW)
      CALL WLINE(DSRN,LBW,NSW,BUF,16)
      DO 480 K=0,6
        CALL TEXT(DMSG,28,K,BUF(2*NWW-359),2)
      CALL WLINE(DSRN,LBW,NSW,BUF,02)
C WRITE DATE
  480 CONTINUE
      CALL ZIA(BUF,NWW)
      CALL WLINE(DSRN,LBW,NSW,BUF,04)
        SPAR(1)=LBW
        CALL PLABEL(DSRN,SPAR,LAB)
C REWRITE LABEL WITH CORRECT NL
      L=0
      LBW=0
        IF(ISW5.NE.1) GOTO 500
        CALL CLOSE(T)
        CALL WEF
        CALL WEF
        CALL BSF
500     CALL CLOSE(DSRN)
      RETURN
      END


C***********
C          *
C   BAND   *
C          *
C***********
C
C FIND WAVEFORM AND FOURIER COEFFICIENTS FOR BANDED CHROMOSOMES
C
        COMMON /C1/ NOB,IDIR
        COMMON /C1/ CHDIR,SMLBUF,LRGBUF,NS,NL,CUROLN
        COMMON /C1/ SST,EST
        COMMON /C1/ SPIOD,SPLTH,SPAREA
        COMMON /C1/ NCHR
        COMMON /C1/ CFOUR,PHI
        COMMON /C1/ BAND,AHIS
        COMMON /C1/ OBUF,BUF
        BYTE LRGBUF(79,88)
        BYTE OBUF(4152)
        BYTE TEMPB
        LOGICAL OPT1,OPT2,OPT3,SEL(60)
        INTEGER TEMPI
        INTEGER SPAR(5),OFS(72)
        INTEGER BMAX
        INTEGER BAND(160)
        INTEGER KPAR(200)
        INTEGER BPL
        INTEGER CHDIR(15,60)
        INTEGER CUROLN
        INTEGER PAR(10)
        INTEGER CLPARM(130)
        REAL CFOUR(69,8),PHI(60,8)
        REAL AHIS(150)
        REAL COSINE(150),SINE(150)
        REAL AFOUR(60,8),BFOUR(60,8)
C
        EQUIVALENCE(XP,PP,QQ,SIGX,JX2,YSTAR,AF,JDIF)
        EQUIVALENCE(YP,PPP,QQQ,SIGY,IY2,YEND,BF,JUY)
        EQUIVALENCE(XTERM,PPPP,NSL,NNZ,LPG,EL,RM,JUL)
        EQUIVALENCE(YTERM,PPPPP,NLL,LL,NG,NDIV,RMJ,JLL)
```

```
      EQUIVALENCE(SPAR(2),BPL)
      EQUIVALENCE (CFOUR(1,1),AFOUR(1,1))
      EQUIVALENCE (PHI(1,1),BFOUR(1,1))
      EQUIVALENCE (NL,NLO)
      EQUIVALENCE (NUMOB,II)
      DATA LWIN/8/,OPT1/.FALSE./,OPT2/.FALSE./,OPT3/.FALSE./
C LENGTH OF WINDOW FOR WAVEFORM CALCULATION ON STRAIGHT CHROMOSOMES
      DATA SEL/60*.TRUE./
C
      PAR(1)=0
      CALL RPARAN(NPAR,PAR,10)
      NP=1
      DO 10 NP=1,NPAR,2
      IF(PAR(NP).EQ.'WA') OPT2=.TRUE.
      IF(PAR(NP).EQ.'AX') OPT3=.TRUE.
      IF(PAR(NP).NE.'QB') GOTO 10
      OPT1=.TRUE.
      DO 8 I=1,60
8     SEL(I)=.FALSE.
10    CONTINUE
C
      CALL AFILE(OBUF,1,'RCR      ',*13,*13)
      CALL OPEN(OBUF,2049,1,0,'RCR')
      CALL GLABEL(OBUF,SPAR,IB)
      IB=0
C
      CALL GET(OBUF,1,IB)
      CALL MVL(OBUF(IB+3),SPIOD,12)
      NCHR=IV(OBUF(IB+17))
      CALL MVL(OBUF(IB+31),CHDIR(1,1),2*15*30)
      CALL GET(OBUF,2,IB)
      CALL MVL(OBUF(IB+31),CHDIR(1,31),2*15*30)
      CALL GET(OBUF,3,IB)
      CALL MVW(OBUF(217+IB),OFS,72)
      IF(.NOT.OPT1) GOTO 30
      DO 20 I=19,34
      IF(OFS(I).EQ.0) GOTO 20
      SEL(OFS(I))=.TRUE.
20    CONTINUE
30    CONTINUE
C
      DO 310 II=1,NCHR
      IF(.NOT.SEL(II)) GOTO 310
      CUROLN=CHDIR(1,II)
      NL=CHDIR(2,II)
      IF(CUROLN.EQ.0) NL=0
      NS=CHDIR(3,II)
      IF(NL.LT.1.OR.NS.LT.1) GO TO 310
      NG=0
      LPG=1024/NS
C     LINES/GET
C
      DO 308 I=1,NL
      CALL GET(OBUF,CUROLN,IB)
      IF(I.EQ.1) LASTIB=IB
      CUROLN=CUROLN+1
      DO 301 III=1,LPG
      NG=NG+1
C     WRITE(5,2000) (OBUF(J+IB),J=1,NS)
      CALL MVL(OBUF(IB+1),LRGBUF(1,NG),NS)
      IB=IB+NS
      IF(NG.GE.NL)GO TO 311
301   CONTINUE
308   CONTINUE
311   CONTINUE
C
C     TEST THE ORIENTATION
C     SCAN ALONG X (ROW) DIRECTION
C
      JX2=NS/2
      IY2=NL/2
      NNZ=0

      NSEGX=0
      NSEGY=0
C
```

```
      DO 400 J=1,NS
      IF(LRGBUF(J,IY2).NE.0) NNZ=NNZ+1
      IF(LRGBUF(J,IY2).EQ.0) NNZ=0
      IF(NNZ.EQ.3) NSEGX=NSEGX+1
  400 CONTINUE
C
C     NOW SCAN IN THE Y (COLUMN) DIRECTION
C
      NNZ=0
C
      DO 401 I=1,NL
      IF(LRGBUF(JX2,I).NE.0) NNZ=NNZ+1
      IF(LRGBUF(JX2,I).EQ.0) NNZ=0
      IF.NNZ.EQ.3) NSEGY=NSEGY+1
  401 CONTINUE
C
C     DECIDE IF IT IS PROBABLY BENT OR NOT MAYBE
C
      IF(NS.GT.25) GO TO 430
      IF(NSEGX.EQ.1.AND.NSEGY.EQ.1) GO TO 410
      IF(NSEGX.GT.1.AND.NSEGY.EQ.1) GO TO 420
      IF(NSEGX.EQ.1.AND.NSEGY.GT.1) GO TO 430
      GO TO 440
C
  410 CONTINUE
C
C     STRAIGHT
C
      DO 411 I=1,NL
      LAST0=0
      DO 405 J=1,NS
      IF(LRGBUF(J,I).NE.0) GO TO 406
      LAST0=J
  405 CONTINUE
  406 CONTINUE
      FIRST0=NS+1
      DO 407 J=1,NS
      J1=NS+1-J
      IF(LRGBUF(J1,I).NE.0) GO TO 408
      FIRST0=J1
  407 CONTINUE
  408 CONTINUE
      LL=(LAST0+FIRST0+1)/2
      IBAND=0
      IL=LAST0+1
      IH=FIRST0-1
      IHMIL=IH-IL+1
      IF(IHMIL.LE.LWIN) GOTO 4200
C IF WIDTH IS LE WINDOW WIDTH GOTO 4200
      IK=LAST0+LWIN
      DO 4100 J=IL,IK
 4100 IBAND=IBAND+LRGBUF(J,I)
      MBAND=IBAND
C MBAND IS MAXIMUM VALUE OF LWIN SAMPLES
 4150 IK=IK+1
      IBAND=IBAND-LRGBUF(IL,I)+LRGBUF(IK,I)
C MOVE ONE PLACE OVER
      IL=IL+1
      IF(IBAND.GT.MBAND) MBAND=IBAND
      IF(IK.LT.IH) GOTO 4150
C CHECK IF ALL SAMPLES PROCESSED
      BAND(I)=MBAND/LWIN
      GOTO 4095
 4200 DO 409 J=IL,IH
  409 IBAND=IBAND+LRGBUF(J,I)
      BAND(I)=IBAND/IHMIL
 4095 CONTINUE
      IF(OPT3) LRGBUF(LL,I)=1
  411 CONTINUE
C
C
      GO TO 440
  420 CONTINUE
C
C     FLIP IT DIAGONALLY
```

```
 430    CONTINUE
C
C       BENT AND PROPERLY ORIENTED
C
C       AVE Y   (I)
C
        NLL=((NL/3)*3)+1
        NP=0
        NSIGY=0
C
        DO 431 I=1,NLL,3
        DO 431 J=1,NS
        IF(LRGBUF(J,I).EQ.0) GO TO 431
        NP=NP+1
        NSIGY=NSIGY+FLOAT(I)
 431    CONTINUE
        IZERO=NSIGY/NP
C
C       AVE X   (J)
C
        NSL=((NS/3)*3)+1
        NP=0
        NSIGX=0
        DO 422 J=1,NSL,3
        DO 422 I=1,NL
        IF(LRGBUF(J,I).EQ.0) GO TO 422
        NP=NP+1
        NSIGX=NSIGX+J
 422    CONTINUE
        JZERO=NSIGX/NP
C
        A11=0.0
        A21=0.0
        A12=0.0
        A22=0.0
        A13=0.0
        A31=0.0
        A32=0.0
        A23=0.0
        S=0.0
        T=0.0
        A33=0.0
        U=0.0
C
C
C
        NSM2=NS-2
        DO 500 J=1,NSM2,3
        DO 500 I=1,NL
C
        IF(LRGBUF(J,I).EQ.0) GO TO 500
        XP=J-JZERO
        YP=I-IZERO
        A33=A33+1.0
        XTERM=XP
        YTERM=YP
        A23=A23+YTERM
        U=U+XTERM
        T=T+XTERM*YTERM
        YTERM=YTERM*YP
        S=S+XTERM*YTERM
        A22=A22+YTERM
        YTERM=YTERM*YP
        A21=A21+YTERM
        YTERM=YTERM*YP
        A11=A11+YTERM
C
 500    CONTINUE
C
        A12=A21
        A13=A22
        A31=A13
        A23=A32
        PP=S*A22*A33+A23*(A12*U+A13*T)
        PPP=U*A22*A13+A23*A23*S+A33*T*A12
```

```
      PPPP=A11*A22*A33+A12*A23*(A22+A13)
      PPPPP=A22*A22*A13+A23*A23*A11+A33*A12*A12
      P=(PP-PPP)/(PPPP-PPPPP)
      QQ=A23*(S-A11*P)-A13*(T-A12*P)
      QQQ=A12*A23-A13*A22
      Q=QQ/QQQ
      R=(S-A11*P-A12*Q)/A13
C
C
C
      NDIV=3
C
C
C
      DO 700 I=1,NL
      YP=I-IZERO
      DXDY=2.0*P*YP+Q
      DYDX=1.0/DXDY
      DY=DXDY
      XP=P*(I-IZERO)**2+Q*(I-IZERO)+R+JZERO
C
      MJ=XP+0.5
      MI=YP+IZERO+0.5

      IF(OPT3) LRGBUF(MJ,MI)=1
C
      BAND(I)=LRGBUF(MJ,MI)
C
      MI=YP+IZERO+0.5-DY
      MJ=XP+1.5
C
      IF(MI.LE.0)GO TO 701
      IF(MI.GT.NL) GO TO 701
      BAND(I)=BAND(I)+LRGBUF(MJ,MI)
C
      MI=YP+IZERO+0.5+DY
      MJ=XP-0.5
C
      IF(MI.LE.0) GO TO 701
      IF(MI.GT.NL) GO TO 701
      BAND(I)=BAND(I)+LRGBUF(MJ,MI)
C
      GO TO 702
C
  701 CONTINUE
      NDIV=2
      BAND(I)=BAND(I)/NDIV
      NDIV=3
  702 CONTINUE
      BAND(I)=BAND(I)/NDIV
  700 CONTINUE
C
C     CALCULATE LENGTH
C
      PT2=P+P
      YSTAR=-Q/PT2
      YEND=FLOAT(NL)/2.0-YSTAR
      PYE=P*YEND
      PPYE=PYE+PYE
      EL=PPYE*SQRT(PPYE*PPYE+1.0)+ALOG(PPYE+SQRT(PPYE*PPYE+1.0))
C     CHDIR(4,II)=EL/PT2+0.5
C
C USE MOB LENGTH DUE TO UNUSUAL RESULTS !
C
  440 CONTINUE
C
C
C
C     FOURIER COEFFICIENTS
C
C
C
      BMAX=BAND(1)
      DO 710 I=2,NL
      IF(BAND(I).GT.BMAX) BMAX=BAND(I)
```

```
 710    CONTINUE
C
       DO 711 I=1,NL
       AMIS(I)=(BAND(I)*100)/AMAX
 711   CONTINUE
C
       NHARM=8
       FNLO=FLOAT(NL-1)
       PIL=6.2832/FNLO
C
       CALL SSWTCH(4,ISW4)
       IF(ISW4.EQ.1) CALL TIMER
C
       NLHALF=(NL+1)/2
       DO 5020 J=1,NLHALF
       RMJ=FLOAT(J-1)*PIL
       LRMJI=J
       COSINE(LRMJI)=COS(RMJ)
       SINE(LRMJI)=SIN(RMJ)
       NLMJP1=NL-J+1
       COSINE(NLMJP1)=COSINE(LRMJI)
       SINE(NLMJP1)=-SINE(LRMJI)
 5020  CONTINUE
C
       DO 5050 I=1,NHARM
       AF=0.0
       BF=0.0
       IM1=I-1
       RM=FLOAT(IM1)*PIL
C
       DO 5010 J=1,NL
       JM1=J-1
C      RMJ=RM*FLOAT(J-1)
       LRMJI=JM1*IM1
       LRMJI=MOD(LRMJI,NL-1)+1
C
       AF=AF+AMIS(J)*COSINE(LRMJI)
       BF=BF+AMIS(J)*SINE(LRMJI)
 5010  CONTINUE
C
       AF=(AF+AF)/FNLO
       BF=(BF+BF)/FNLO
C
       COEUR(NUMOB,I)=SQRT(AF*AF+BF*BF)
       PHI(NUMOB,I)=ATAN2(BF,AF)
C
 5050  CONTINUE
       IF(ISW4.EQ.1) CALL TIMER
C
       IF(.NOT.OPT2) GO TO 810
       DO 811 I=1,NL
       JUV=(AMIS(I)/100.0)*AMINO(NS,20)
C MAX WIDTH OF WAVEFORM IS 20 SAMPLES
       JDIF=NS-JUV
       JLL=JDIF/2+1
       JUL=NS-JDIF/2
       DO 812 J=1,JLL
 812   LRGBUF(J,I)=0
       DO 813 J=JLL,JUL
 813   LRGBUF(J,I)=127
       DO 814 J=JUL,NS
 814   LRGBUF(J,I)=0
 811   CONTINUE
 810   CONTINUE
C
       IF(.NOT.OPT3.AND..NOT.OPT2) GO TO 318
C
       CUROLN=CHDIR(1,II)
       NG=0
       LPG=1024/NS
C
       DO 800 I=1,NL
       CALL GET(OBUF,CUROLN,IB)
       DO 831 III=1,LPG
       NG=NG+1
```

```
      CALL MVL(LRGBUF(1,NG),OBUF(IB+1),NS)
      IB=IB+NS
      IF(NG.GE.NL) GO TO 842
  831 CONTINUE
  842 CONTINUE
      CALL PUT(OBUF,CUROLN,IB)
      CUROLN=CUROLN+1
      IF(NG.GE.NL) GO TO 841
  808 CONTINUE
  841 CONTINUE
C
  318 CONTINUE
C
C     OUTPUT FOURIER COEF'S TO FILE RCR
C
      CALL PUT(OBUF,4,IB)
      CALL MVU(CFOUR(1,1),OBUF(IB+1),480)
      CALL PUT(OBUF,5,IB)
      CALL MVU(CFOUR(1,5),OBUF(IB+1),480)
      CALL PUT(OBUF,6,IB)
      CALL MVU(PHI(1,1),OBUF(IB+1),480)
      CALL PUT(OBUF,7,IB)
      CALL MVU(PHI(1,5),OBUF(IB+1),480)
C
      CALL CLOSE(OBUF)
C
C     CREATE PARAMETERS FOR PHASE 14 (CLAS)
C
      DO 4080 I=1,NCHR
      CLPARM(9+2*I)=CHDIR(4,I)
      CLPARM(10+2*I)=CHDIR(8,I)
      IF(CHDIR(1,I).EQ.0) CLPARM(9+2*I)=0
      IF(CHDIR(1,I).EQ.0) CLPARM(10+2*I)=0
C IF BLKNO IS ZERO, THE CHROMOSOME WAS REJECTED BY MOB
 4080 CONTINUE
C
C     SET UP PART OF CHROMOSOME DIRECTORY FOR NEXT PHASE
C
      CLPARM(1)=NCHR
C
C     POSITIONS 2 THRU 10 MAY BE REGARDED AS SPARE
C
      CALL UPARAM(130,CLPARM,15)
      IF(SW2.EQ.1) CALL APHASE(10)
C IF SW8 IS UP, CALL KTYPE INSTEAD OF FOUR
      IF(OPT2.OR.OPT3) CALL APHASE(10)
      CALL EXIT
      END
      SUBROUTINE FOUR
      COMMON /C1/ CHDIR,SMLBUF,LRGBUF,NS,NL,CUROLN
      COMMON /C1/ SPIOD,SPLTH,SPAREA
      COMMON /C1/ NCHR
      COMMON /C1/ CFOUR,PHI
      COMMON /C1/ OBUF,BUF
        INTEGER JV(50),IITAB(100),JJTAB(100)
        BYTE JMSG(132)
      BYTE OBUF(2124)
        BYTE C(3640)
        REAL LTAB(60),CTAB(60)
        INTEGER START(25),INCR(25),MNC(25)
        INTEGER LOFS(91)
        INTEGER OFS(118),KPAR(92)
        INTEGER CLPARM(130)
        INTEGER CPAR(5)
        INTEGER SPAR(5)
        INTEGER CUROLN
        INTEGER PPL
      REAL CFOUR(60,10),PHI(60,10)
      INTEGER NCHROM(24)
      INTEGER CLASS(60)
        BYTE MSG(30)
      REAL DIST(18)
      REAL VECTOR(18)
      REAL LIKLE(60,24)
```

```
      REAL MU(18,24)
      REAL SIGMA(18,24)
      REAL MBUF(18,24)
      REAL SBUF(18,24)
C
      EQUIVALENCE(MBUF(1,1),C(57))
      EQUIVALENCE(SBUF(1,1),C(1785))
      EQUIVALENCE(SBUF(1,1),SIGMA(1,1))
      EQUIVALENCE(MBUF(1,1),MU(1,1))
      EQUIVALENCE(KPAR(3),OFS(1))
C
      DATA NMEAS/16/,LMEAS/11/,IMEAS/5/,JMEAS/12/
      DATA VMAX1/36./,VMAX2/36./,VMAX3/50./,VMAX4/50./,VMAX5/64./
      DATA IS1/19/,IS2/34/
      DATA JC1/6/,JC2/13/
C SLOTS TO BE CLASSIFIED WITH HYBRID CLASSIFIER
      DATA NEXTPH/28/
C NEXT PHASE TO CALL FOR HYBRID CLASSIFIER
      DATA K1MEAS/2/,K2MEAS/3/,KXMEAS/1/,NGROUP/24/
      DATA START/ 1,5,9,13,15,19,21,23,25,
     1    27,29,31,37,39,41,45,49,51,
     1    55,57,65,67,34,70,74                    /
      DATA INCR/22*1,-1,-1,1/
      DATA MNC/23*2,1,46/
      DATA OFS/118*0/
      DATA NCHROM/24*0/
      DATA CLASS /60*0/
C
C     OBTAIN PARAMETERS, LENGTH AND CENTROMERE INDEX,
C     AS WELL AS THE NUMBER OF CHROMOSOMES IN THE SPREAD
C
      CALL RPARAM(NPAR,CLPARM,130)
      CALL SSWTCH(4,ISW4)
      IF(ISW4.EQ.1) PAUSE 15
C PAUSE IF SW4 IS UP
C
      NCHR=CLPARM(1)
C
C     READ BACK FOURIER COEF'S PRODUCED BY BAND (PHASE 14)
C
      CALL AFILE(OBUF,1,'RCR       ',*13,*13)
      CALL OPEN(OBUF,1024,1,0,'RCR')
      CALL GLABEL(OBUF,SPAR,IB)
      IF(OBUF(IB+104).EQ.*115) MNC(23)=1
      IF(OBUF(IB+104).EQ.*106) MNC(24)=0
C
C CHECK FOR SEX OF M OR F AND CHANGE X AND Y MAX
C
      CALL GET(OBUF,3,IB)
      CALL MVL(OBUF(217+IB),LOFS(1),182)
C
      CALL GET(OBUF,4,IB)
      CALL MVL(OBUF(1+IB),CFOUR(1,1),960)
C
      CALL GET(OBUF,5,IB)
      CALL MVL(OBUF(1+IB),CFOUR(1,5),960)
C
      CALL GET(OBUF,6,IB)
      CALL MVL(OBUF(1+IB),PHI(1,1),960)
C
      CALL GET(OBUF,7,IB)
      CALL MVL(OBUF(1+IB),PHI(1,5),960)
C
C
C
C*************************************************************
C
C     THE HYBRID CLASSIFIER USES RESULTS OF
C     THE CONVENTIONAL CLASSIFIER
C
      CALL SSWTCH(7,ISW7)
      IF(ISW7.NE.1) GOTO 800
C GOTO 800 FOR THE HYBRID CLASSIFIER
C
```

```
C SW7 UP IS FOR A FULL FOURIER CLASSIFIER
      IS1=1
      IS2=90
      JC1=1
      JC2=24
      NEXTPH=9
      GOTO 820
800   CONTINUE
      CALL MVW(LOFS,OFS,90)
      CALL ZIA(OFS(IS1),35-IS1)
C FOUR WILL CLASSIFY THE C GROUP STARTING WITH IS1
      CALL ZIA(OFS(13),4)
      CALL ZIA(OFS(37),6)
      CALL ZIA(OFS(55),4)
      CALL ZIA(OFS(65),4)
C KFIX WILL CLASSIEY B,D,F, AND G
C
C
820   IF(NCHR.LE.46) GOTO 830
C IF MORE THAN 46, ALLOW FOR 2 X AND 2 Y
      MNC(23)=2
      MNC(24)=2
830   CONTINUE
C
C     GET MEANS AND SIGMAS
C
      CALL AFILE(C,4,'CDATA    ',*6,*6)
      CALL OPEN(C,3504,0,0,'CDA')
      CALL GLABEL(C,CPAR,IC)
      CALL GET(C,1,IC)
895   CONTINUE
C
      ITOTL=0
      NRELCH=NCHR
      DO 899 II=1,NCHR
      IF(CLPARM(9+2*II).EQ.0) NRELCH=NRELCH-1
      ITOTL=ITOTL+CLPARM(9+2*II)
 899  CONTINUE
      FTOTL=46.*ITOTL/NRELCH
      DO 4000 I=1,NCHR
      LTAB(I)=(CLPARM(9+2*I)*10000.)/FTOTL
      CTAB(I)=CLPARM(10+2*I)
C STORE REAL LENGTH AND CI
4000  CONTINUE
C
C
      DO 896 II=1,NCHR
      DO 896 JJ=1,NGROUP
      LIKLE(II,JJ)=999.
 896  CONTINUE

C
C
      CALL SSWTCH(8,ISW8)
      IF(ISW8.EQ.1) CALL QPRINT('1
     1     OBJ     GROUP      DLEN      DCIA      VLEN      VCIA
     2      VCSUM      VPSUM      TVAR')
C
      DO 900 IS=IS1,IS2
      II=LOFS(IS)
      IF(II.EQ.0) GOTO 900
C
      IF(ISW8.EQ.1) CALL QPRINT(' ')
C
      DO 903 IJ=JC1,JC2
      JJ=IJ
      IF(JJ.EQ.13.AND.ISW7.NE.1) JJ=23
C
      SIG112=SIGMA(K1MEAS,JJ)
      SIG222=SIGMA(K2MEAS,JJ)
      IF(SIG112.LT.0.00001) SIG112=.00001
      IF(SIG222.LT.0.00001) SIG222=.00001
C
      DIST(1)=LTAB(II)-MU(K1MEAS,JJ)
      DIST(2)=CTAB(II)-MU(K2MEAS,JJ)
```

```
      VECTOR(1)=(DIST(1)/SIG112)*DIST(1)
      IF(VECTOR(1).GT.VMAX1) GOTO 903
      VECTOR(2)=(DIST(2)/SIG222)*DIST(2)
      IF(VECTOR(2).GT.VMAX2) GOTO 903
C
      FSUM=0.0
      DO 907 I=IMEAS,LMEAS
      DISTI=CFOUR(II,I-3)-MU(I,JJ)
      FSUM=FSUM+(DISTI*DISTI/SIGMA(I,JJ))
907   CONTINUE
      IF(FSUM.GT.VMAX3) GOTO 903
      PSUM=0.0
      IF(JMEAS.EQ.0) GOTO 9080
      DO 908 I=JMEAS,NMEAS
      DISTI=PHI(II,I-10)-MU(I,JJ)
      IF(DISTI.GT.3.1416) DISTI=6.2832-DISTI
      IF(DISTI.LT.-3.1416) DISTI=-6.2832-DISTI
      PSUM=PSUM+DISTI*DISTI/SIGMA(I,JJ)
908   CONTINUE
      IF(PSUM.GT.VMAX4) GOTO 903
9080  LIKLE(II,JJ)=VECTOR(1)+VECTOR(2)+FSUM+PSUM
      CALL SSWTCH(0,ISW0)
      IF(ISW0.NE.1) GO TO 9010
      JV(1)=II
      JV(2)=JJ
      JV(3)=DIST(1)
      JV(4)=DIST(2)
      JV(5)=VECTOR(1)
      JV(6)=VECTOR(2)
      JV(7)=FSUM
      JV(8)=PSUM
      JV(9)=LIKLE(II,JJ)
      DO 9009 I=1,9
9009  CALL OUTCON(JV(I),JMSG(10*I),10)
      CALL QPRINT(JMSG,90)
9010  CONTINUE
C
 903  CONTINUE
 900  CONTINUE
C
C
      DO 952 IK=1,NCHR
      ELMIN=VMAX5
      IISAV=0
C
      DO 950 IJ=JC1,JC2
      JJ=IJ
      IF(JJ.EQ.13.AND.ISW7.NE.1) JJ=23
      IF(NCHROM(JJ).GE.MNC(JJ)) GO TO 950
C
C IGNORE GROUPS THAT ARE FULL
C LOOK FOR UNCLASSIFIED CHROMOSOMES
C
      DO 951 IS=IS1,IS2
      II=LOFS(IS)
      IF(II.EQ.0) GOTO 951
      IF(CLASS(II).NE.0) GO TO 951
      IF(LIKLE(II,JJ).GE.ELMIN) GOTO 953
      ELMIN=LIKLE(II,JJ)
      IISAV=II
      JJSAV=JJ
 953  CONTINUE
 951  CONTINUE
C
 950  CONTINUE
C
      IF(IISAV.EQ.0) GO TO 960
      CLASS(IISAV)=JJSAV
      NCHROM(JJSAV)=NCHROM(JJSAV)+1
      OFS(START(JJSAV))=IISAV
      START(JJSAV)=START(JJSAV)+INCR(JJSAV)
 952  CONTINUE
C
 960  CONTINUE
C
```

```
C LOOK FOR UNCLASSIFIED AND SEE IF MOVES CAN BE MADE
C ORDER UP TO 100 LIKELIHOODS IN IITAB AND JJTAB
C
      DO 300 IK=1,100
      ELMIN=VMAX5
      DO 250 IS=IS1,IS2
      II=LOFS(IS)
      IF(II.EQ.0) GOTO 250
      IF(CLASS(II).NE.0) GOTO 250
      DO 240 IJ=JC1,JC2
      JJ=IJ
      IF(JJ.EQ.13.AND.ISW7.NE.1) JJ=23
      IF(MNC(JJ).EQ.0) GOTO 240
      IF(LIKLE(II,JJ).GE.ELMIN) GOTO 240
      ELMIN=LIKLE(II,JJ)
      IISAV=II
      JJSAV=JJ
240   CONTINUE
250   CONTINUE
      IF(ELMIN.EQ.VMAX5) GOTO 320
C IF NO MORE LIKELY CLASSIFICATIONS GOTO 320
      IITAB(IK)=IISAV
      JJTAB(IK)=JJSAV
      LIKLE(IISAV,JJSAV)=998
C RAISE LIKLE
300   CONTINUE
C
      IK=101
320   IK=IK-1
      IF(IK.EQ.0) GOTO 520
      DO 500 K=1,IK
      II=IITAB(K)
      J=JJTAB(K)
      IF(CLASS(II).NE.0) GOTO 500
C SEE IF WE CAN MOVE SOMEONE OUT OF GROUP J INTO A LIGHT GROUP
      JS1=START(J)-NCHROM(J)*INCR(J)
      JS2=START(J)-INCR(J)
      IF(JS1.GT.JS2) CALL SWAP(JS1,JS2)
      ELMIN=VMAX5
      DO 450 JS=JS1,JS2
      I=OFS(JS)
      DO 440 IJ=JC1,JC2
      JJ=IJ
      IF(JJ.EQ.13.AND.ISW7.NE.1) JJ=23
      IF(NCHROM(JJ).GE.MNC(JJ)) GOTO 440
      IF(LIKLE(I,JJ).GE.VMAX5) GOTO 440
      DLIK=LIKLE(I,JJ)-LIKLE(I,J)
C DLIK IS A MEASURE OF THE LIKELIHOOD THAT I BELONGS TO GROUP JJ
C AND DOESN'T BELONG TO GROUP J
      IF(DLIK.GE.ELMIN) GOTO 440
      ELMIN=DLIK
      ISAV=I
      JSSAV=JS
      JJSAV=JJ
440   CONTINUE
450   CONTINUE
      IF(ELMIN.EQ.VMAX5) GOTO 500
C IF NO MOVE OUT OF J CAN BE MADE, GOTO 500
C OTHERWISE, MOVE OBJECT ISAV FROM SLOT JSSAV TO GROUP JJSAV
C THEN, MOVE OBJECT II TO SLOT JSSAV
      CLASS(ISAV)=JJSAV
      NCHROM(JJSAV)=NCHROM(JJSAV)+1
      OFS(START(JJSAV))=ISAV
      START(JJSAV)=START(JJSAV)+INCR(JJSAV)
C
      CLASS(II)=J
      OFS(JSSAV)=II
500   CONTINUE
C
520   CONTINUE
C
C CHECK FOR STILL UNCLASSIFIED AND PUT AT BOTTOM
C
      DO 980 IS=IS1,IS2
      II=LOFS(IS)
      IF(II.EQ.0) GOTO 990
```

```
      IF(CLASS(II).NE.0) GOTO 980
      CLASS(II)=25
965   IF(START(25).GE.90) GOTO 980
      START(25)=START(25)+1
      IF(OFS(START(25)).NE.0) GOTO 965
      OFS(START(25))=II
980   CONTINUE
C
      CALL MVL('OS  ',KPAR,4)
      CALL QPARAM(92,KPAR,NEXTPH)
C
C
      CUROLN=7
      CALL GET(OBUF,CUROLN,IB)
      CALL MVL(CLASS(1),OBUF(961+IB),60)
      CALL PUT(OBUF,CUROLN,IB)
C
      CALL CLOSE(OBUF)
      CALL APHASE(NEXTPH)
C
      IF(ISW0.EQ.1) CALL QPRINT('1')
      RETURN
      END


C***********
C           *
C   KFIX    *
C           *
C***********
C
C       CHROMOSOME CLASSIFIER PART 3
C       SYNTACTICAL CORRECTION OF CLASSIFICATION
C
      SUBROUTINE KFIX
      COMMON /C1/ NOB,IDIR
      COMMON /C1/ CHDIR,SMLBUF,LRGBUF,NS,NL,CUROLN
      COMMON /C1/ SST,EST
      COMMON /C1/ SPIOD,SPLIN,SPAREA
      COMMON /C1/ NCHR
      COMMON /C1/ CFOUR,PHI
      COMMON /C1/ BAND,AHIS
      COMMON /C1/ OBUF,BUF
      BYTE LRGBUF(78,88)
      BYTE OBUF(2124)
      LOGICAL BGROUP(60)
      LOGICAL DGROUP(60)
      LOGICAL GGROUP(60)
      LOGICAL FGROUP(60)
      LOGICAL EGROUP(60)
      INTEGER IIBCHR(6)
      INTEGER DPOINT(6)
      INTEGER IIDCHR(6)
      INTEGER IIFCHR(6)
      INTEGER IIGCHR(6)
      INTEGER KPAR(92)
      INTEGER OFS(91)
      INTEGER LOFS(90)
      INTEGER IPROF(90)
      INTEGER JPROF(90)
      INTEGER KGBAND(6)
      INTEGER JFETUR(20)
      INTEGER SPAR(5)
      INTEGER BMAX
      INTEGER BPL
      INTEGER CHDIR(15,60)
      INTEGER CUROLN
      INTEGER PAR(10)
      REAL BD(6)
      REAL GD(6)
      REAL RATIO(12)
      REAL CFOUR(60,15),PHI(60,15)
      REAL AFOUR(60,15),BFOUR(60,15)
```

```
C
      EQUIVALENCE (KPAR(3),OFS(1))
      EQUIVALENCE(SPAR(2),BPL)
      EQUIVALENCE (CFOUR(1,1),AFOUR(1,1))
      EQUIVALENCE (PHI(1,1),BFOUR(1,1))
      EQUIVALENCE (NL,NLO)
      EQUIVALENCE (NUMOB,II)
C
      DATA ND/0/
      DATA NDCHR/0/
      DATA DGROUP/60*.FALSE./
      DATA GGROUP/60*.FALSE./
      DATA FGROUP/60*.FALSE./
      DATA EGROUP/60*.FALSE./

C
      CALL AFILE(OBUF,1,'RCR      ',*13,*13)
      CALL OPEN(OBUF,1024,1,0,'RCR')
      CALL GLABEL(OBUF,SPAR,IB)
C
      CALL RPARAM(NPAR,KPAR,92)
C
C     READ RESULTS OF CONVENTIONAL CLASSIFICATION AND
C     EXTRACT GROUP CLASSIFICATIONS
C
C             D-GROUP
C
      CALL GET(OBUF,3,IB)
      CALL MVL(OBUF(217+IB),LOFS(1),182)
C
C
C
      DO 104 I=37,42
      IIDCHR(I-36)=0
      ILOFS=LOFS(I)
      IF(ILOFS.EQ.0) GO TO 104
      DGROUP(ILOFS)=.TRUE.
      IIDCHR(I-36)=ILOFS
  104 CONTINUE
C
C             B-GROUP
C
      DO 102 I=13,16
      IIBCHR(I-12)=0
      ILOFS=LOFS(I)
      IF(ILOFS.EQ.0) GO TO 102
      BGROUP(ILOFS)=.TRUE.
      IIBCHR(I-12)=ILOFS
  102 CONTINUE
C
C             E-GROUP
C
      DO 1050 I=45,46
      ILOFS=LOFS(I)
      IF(ILOFS.EQ.0) GO TO 1050
      EGROUP(ILOFS)=.TRUE.
 1050 CONTINUE
      DO 1051 I=49,52
      ILOFS=LOFS(I)
      IF(ILOFS.EQ.0) GO TO 1051
      EGROUP(ILOFS)=.TRUE.
 1051 CONTINUE
C
C     F-GROUP
C
      DO 106 I=55,58
      IIFCHR(I-54)=0
      ILOFS=LOFS(I)
      IF(ILOFS.EQ.0) GO TO 106
      FGROUP(ILOFS)=.TRUE.
      IIFCHR(I-54)=ILOFS
  106 CONTINUE
C
C             G-GROUP, INCLUDING Y
```

```
C
      DO 107 I=65,70
      IIGCHR(I-64)=0
      ILOFS=LOFS(I)
      IF(ILOFS.EQ.0) GO TO 107
      GGROUP(ILOFS)=.TRUE.
      IIGCHR(I-64)=ILOFS
107   CONTINUE
C
C     GET CHROMOSOME DIRECTORY
C
      CALL GET(OBUF,1,IB)
      CALL MVL(OBUF(IB+3),SPIOD,12)
      NCHR=IV2(OBUF(IB+17))
      CALL MVL(OBUF(IB+31),CHDIR(1,1),2*15*30)
      CALL GET(OBUF,2,IB)
      CALL MVL(OBUF(IB+31),CHDIR(1,31),2*15*30)
C
      JAY=0
      DO 310 IX=1,6
      II=IIDCHR(IX)
C
      IF(DGROUP(II)) GO TO 304
      GO TO 310
304   CONTINUE
C
      JFETUR(1)=0
C
      CUROLN=CHDIR(1,II)
      NL=CHDIR(2,II)
      NS=CHDIR(3,II)
      IF(NL.LT.1.OR.NS.LT.1) GO TO 310
      NG=0
      LPG=1024/NS
C     LINES/GET
C
      DO 300 I=1,NL
      CALL GET(OBUF,CUROLN,IB)
      IF(I.EQ.1) LASTIB=IB
      CUROLN=CUROLN+1
      DO 301 III=1,LPG
      NG=NG+1
      CALL SSWTCH(8,JAY)
      DO 330 J=1,NS
      LRGBUF(J,NG)=OBUF(J+IB)
330   CONTINUE
      IB=IB+NS
      IF(NG.GE.NL)GO TO 311
301   CONTINUE
300   CONTINUE
311   CONTINUE
C
C     . . MAIN LOGIC
C
      IF(.NOT.DGROUP(III)) GO TO 401
C
      NL2=NL/2
      LTOP1=2
      LTOP2=NL2-1
      LBOT1=NL2+1
      LBOT2=NL-1
C
      ISUMT=0
      ISUMB=0
      NTOP=0
      NBOT=0
C
      DO 411 J=LTOP1,LTOP2
      DO 410 I=1,NS
      IVAL=LRGBUF(I,J)
      IF(IVAL.EQ.0) GO TO 410
      ISUMT=ISUMT+IVAL
      NTOP=NTOP+1
```

```
 410    CONTINUE
 411    CONTINUE
        ITOP=ISUMT/NTOP
C
C
C
        DO 421 J=LBOT1,LBOT2
        DO 420 I=1,NS
        IVAL=LRGBUF(I,J)
        IF(IVAL EQ.0) GO TO 420
        ISUMB=ISUMB+IVAL
        NBOT=NBOT+1
 420    CONTINUE
 421    CONTINUE
        IBOT=ISUMB/NBOT
C
        ND=ND+1
        RATIO(ND)=FLOAT(ITOP)/FLOAT(IBOT)
        DPOINT(ND)=II
C
 401    CONTINUE
C
 310    CONTINUE
C
C       DO FOR B-GROUP
C
C
        DO 350 IX=1,4
        II=IIBCHR(IX)
        IF(II.EQ.0) GOTO 350
C
        CUROLN=CHDIR(1,II)
        NL=CHDIR(2,II)
        NS=CHDIR(3,II)
        IBCI=CHDIR(8,II)
        NG=0
        LPG=1024/NS
C
        DO 1800 I=1,NL
        CALL GET(OBUF,CUROLN,IB)
        CUROLN=CUROLN+1
        DO 1801 III=1,LPG
        NG=NG+1
        DO 1830 J=1,NS
        LRGBUF(J,NG)=OBUF(J+IB)
 1830   CONTINUE
        IB=IB+NS
        IF(NG.GE.NL) GO TO 1811
 1801   CONTINUE
 1800   CONTINUE
 1811   CONTINUE
C
C       EXTRACT THE SO-CALLED B-BAND
C
        ISTART=FLOAT(IBCI*NL)/100.0
        ISTART=NL-ISTART
        IEND=ISTART+ISTART-1
        NL2=NL/2
        IF(IEND.GT.NL2) IEND=NL2
C
        NPB=0
        BIOD=0.0
        DO 351 I=ISTART,IEND
        DO 352 J=1,NS
        IVAL=LRGBUF(J,I)
        IF(IVAL.EQ.0) GO TO 352
        BIOD=BIOD+FLOAT(IVAL)
        NPB=NPB+1
 352    CONTINUE
 351    CONTINUE
        BD(IX)=BIOD/FLOAT(NPB)
 350    CONTINUE
C
C       CLASSIFY THE B-GROUP
```

```
C
      DO 360 I=1,4
      DENMAX=0.0
      DO 361 J=1,4
      IF(BD(J).LE.DENMAX) GO TO 361
      IOBJ=IIBCHR(J)
      IF(IOBJ.LT.1) GO TO 361
      DENMAX=BD(J)
      JS=J
  361 CONTINUE
      OFS(12+I)=IOBJ
      BD(JS)=0.0
  360 CONTINUE
C
C     DO FOR F-GROUP
C
      DO 450 IX=1,4
      II=IIFCHR(IX)
      IF(II.EQ.0) GOTO 450
C
      CUROLN=CHDIR(1,II)
      NL=CHDIR(2,II)
      NS=CHDIR(3,II)
      NG=0
      LPG=1024/NS
C
      DO 2300 I=1,NL
      CALL GET(OBUF,CUROLN,IB)
      CUROLN=CUROLN+1
      DO 2301 III=1,LPG
      NG=NG+1
      DO 2330 J=1,NS
      LRGBUF(J,NG)=OBUF(J+IB)
 2330 CONTINUE
      IB=IB+NS
      IF(NG.GE.NL) GO TO 2311
 2301 CONTINUE
 2300 CONTINUE
 2311 CONTINUE
C
C     EXTRACT INTEGRATED OPTICAL DENSITY
C
      GIOD=0.0
      NPG=0
      DO 451 I=1,NL
      DO 452 J=1,NS
      IVAL=LRGBUF(J,I)
      IF(IVAL.EQ.0) GO TO 452
      GIOD=GIOD+FLOAT(IVAL)
      NPG=NPG+1
  452 CONTINUE
  451 CONTINUE
      GD(IX)=GIOD/FLOAT(NPG)
C
  450 CONTINUE
C
C     CLASSIFY THE F-GROUP
C
      DO 460 I=1,4
      DENMAX=0.0
      DO 461 J=1,4
      IF(GD(J).LE.DENMAX) GO TO 461
      IOBJ=IIFCHR(J)
      IF(IOBJ.LT.1) GO TO 461
      DENMAX=GD(J)
      JS=J
  461 CONTINUE
      OFS(59-I)=IOBJ
      GD(JS)=0.0
  460 CONTINUE
C
C     DO FOR G-GROUP
C
      DO 510 IX=1,4
      II=IIGCHR(IX)
      IF(II.EQ.0) GOTO 510
```

```
C
      CUROLN=CHDIR(1,II)
      NL=CHDIR(2,II)
      NS=CHDIR(3,II)
      NG=0
      LPG=1024/NS
C
      DO 1300 I=1,NL
      CALL GET(OBUF,CUROLN,IB)
      CUROLN=CUROLN+1
      DO 1301 III=1,LPG
      NG=NG+1
      DO 1330 J=1,NS
      LRGBUF(J,NG)=OBUF(J+IB)
 1330 CONTINUE
      IB=IB+NS
      IF(NG.GE.NL) GO TO 1311
 1301 CONTINUE
 1300 CONTINUE
 1311 CONTINUE
C
C     EXTRACT DENSITY PROFILES
C
      DO 500 K=1,NL
      NP=0
      IPROF(K)=0
      DO 501 L=1,NS
      IVAL=LRGBUF(L,K)
      IF(IVAL.EQ.0) GO TO 501
      IPROF(K)=IPROF(K)+IVAL
      NP=NP+1
  501 CONTINUE
      IPROF(K)=IPROF(K)/NP
  500 CONTINUE
C
C     ANALYZE THE BANDS IN THE G-GROUP
C
      DO 511 K=1,NL
  511 JPROF(K)=0
C
      NLM2=NL-2
      DO 512 K=3,NLM2
      IV=0
      DO 513 KK=1,5
      IV=IV+IPROF(K+KK-3)
  513 CONTINUE
      JPROF(K)=IV
  512 CONTINUE
      MAX=JPROF(3)
      DO 514 K=4,NLM2
      IF(MAX.GE.JPROF(K)) GO TO 514
      MAX=JPROF(K)
      KBAND=K
  514 CONTINUE
C
      NSAME=0
      DO 515 K=KBAND,NLM2
      IF(JPROF(K).NE.MAX) GO TO 516
      NSAME=NSAME+1
  515 CONTINUE
  516 CONTINUE
      KGBAND(IX)=KBAND+NSAME/2
C
  510 CONTINUE
C
C     CLASSIFY TH G-GROUP
C
      DO 521 I=1,4
      MAXBP=0
      DO 522 J=1,4
      IF(KGBAND(J).LE.MAXBP) GO TO 522
      IOBJ=IIGCHR(J)
      IF(IOBJ.LT.1) GO TO 522
      MAXBP=KGBAND(J)
      JS=J
```

```
  522     CONTINUE
          OFS(64+I)=IOBJ
          KGBAND(JS)=0
  521     CONTINUE
C
C         CLASSIFY THE D-GROUP
C
          DO 601 I=1,6
          RMAX=0.0
          DO 602 J=1,6
          IF(RATIO(J).LE.RMAX) GO TO 602
          IOBJ=DPOINT(J)
          IF(IOBJ.LT.1) GO TO 602
          RMAX=RATIO(J)
          JS=J
  602     CONTINUE
          NDCHR=NDCHR+1
          OFS(43-I)=IOBJ
          RATIO(JS)=0.0
  601     CONTINUE
  600     CONTINUE
C
 1000     FORMAT(I10)
 2000     FORMAT(3X,39I3)
 3000     FORMAT('1CHROMOSOME ',I2)
 4000     FORMAT(10F10.2)
C
          CALL UPARAM(92,KPAR,9)
C
          CALL CLOSE(OBUF)
          CALL APHASE(9)
C
          CALL EXIT
          END
C***********
C           *
C  ABNORM   *
C           *
C***********
C
C         ROUTINE TO ASSESS NORMALITY OF CHROMOSOMES IN A SPREAD
C
          SUBROUTINE ABNORM
          COMMON /C1/ NOB,IDIR
          COMMON /C1/ CHDIR,SMLBUF,LRGBUF,NS,NL,CUROLN
          COMMON /C1/ SST,EST
          COMMON /C1/ SPIOD,SPLTH,SPAREA
          COMMON /C1/ NCHR
          COMMON /C1/ CFOUR,PHI
          COMMON /C1/ BAND,AHIS
          COMMON /C1/ OBUF,BUF
          BYTE LRGBUF(50,90)
          BYTE OBUF(2124)
          BYTE TEMPB
          LOGICAL OPT1,OPT2,OPT3
          INTEGER IPROF(90)
          INTEGER JPETUR(20)
          INTEGER TEMPI
          INTEGER SPAR(5)
          INTEGER BMAX
          INTEGER BAND(180)
          INTEGER BPL
          INTEGER CHDIR(15,60)
          INTEGER CUROLN
C         INTEGER*2 SST(76),EST(76)
          INTEGER PAR(10)
          REAL CFOUR(60,15),PHI(60,15)
          REAL AHIS(180)
          REAL COSINE(150),SINE(150)
          REAL AFOUR(60,15),BFOUR(60,15)
C
C
C
          EQUIVALENCE(SPAR(2),BPL)
          EQUIVALENCE (CFOUR(1,1),AFOUR(1,1))
```

```
      EQUIVALENCE (PHI(1,1),BFOUR(1,1))
      EQUIVALENCE (NL,NLO)
      EQUIVALENCE (NUMOB,II)
      DATA LOPT1/'T1'/
      DATA LOPT2/'T2'/
      DATA LOPT3/'T3'/
      DATA LOP  /'OP'/
C
C
C
 10   CONTINUE
C
C
C
      CALL AFILE(OBUF,1,'RCR      ',*13,*13)
      CALL OPEN(OBUF,1024,1,0,'RCR')
      CALL GLABEL(OBUF,SPAR,IB)
C
C
C
      CALL GET(OBUF,1,IB)
      CALL MVL(OBUF(IB+3),SPIOD,12)
      NCHR=IV(OBUF(IB+17))
      CALL MVL(OBUF(IB+31),CHDIR(1,1),2*15*30)
      CALL GET(OBUF,2,IB)
      CALL MVL(OBUF(IB+31),CHDIR(1,31),2*15*30)
C
C
C
      DO 310 II=1,NCHR
      JFETUR(1)=0
C
      WRITE(5,3000)II
 303  CONTINUE
C
      LASTIB=IB
      CUROLN=CHDIR(1,II)
      NL=CHDIR(2,II)
      NS=CHDIR(3,II)
      IF(NL.LT.1.OR.NS.LT.1) GO TO 310
      NG=0
      LPG=1024/NS
C     LINES/GET
C
      DO 300 I=1,NL
      CALL GET(OBUF,CUROLN,IB)
      IF(I.EQ.1) LASTIB=IB
      CUROLN=CUROLN+1
      DO 301 III=1,LPG
      NG=NG+1
      CALL SSWTCH(0,JAY)
      IF(JAY.EQ.1) WRITE(5,2000) (OBUF(J+IB),J=1,NS)
 302  CONTINUE
      DO 330 J=1,NS
      LRGBUF(J,NG)=OBUF(J+IB)
 330  CONTINUE
      IB=IB+NS
      IF(NG.GE.NL)GO TO 311
 301  CONTINUE
 300  CONTINUE
 311  CONTINUE
C
C
C
C
C     ****************************************
C
C
C
C
C     .. MAIN LOGIC
C
C
C
      NSM1=NS-1
```

```
      NNON0=0
      NMX=0
      NLT0=0
C
C
C
      DO 500 K=1,NL
C
      MAXLOC=1
      LINMAX=LRGBUF(1,K)
C
      DO 510 L=2,NS
      IF(LRGBUF(L,K).LE.LINMAX) GO TO 511
      LINMAX=LRGBUF(L,K)
      MAXLOC=L
  511 CONTINUE
  510 CONTINUE
C
C
C
      JTH=LINMAX/2
      IPROF(K)=NS
C
      DO 530 L=1,NS
      IF(LRGBUF(L,K).GE.JTH) GO TO 532
      IPROF(K)=IPROF(K)-1
  530 CONTINUE
C
  532 CONTINUE
C
      DO 540 L=1,NS
      LL=NS+1-L
      IF(LRGBUF(LL,K).GE.JTH) GO TO 542
      IPROF(K)=IPROF(K)-1
  540 CONTINUE
C
  542 CONTINUE
      IF(IPROF(K).GE.NS) IPROF(K)=0
C
  500 CONTINUE
C
C
C
      IPTOT=0
      NLM2=NL-2
      DO 600 K=3,NLM2
      IPTOT=IPTOT+IPROF(K)
  600 CONTINUE
C
      IPAVE=IPTOT/NLM2
C
      DO 620 K=3,NLM2
      IPROF(K)=IPROF(K)-IPAVE
      IF(IPROF(K).LT.0) NLT0=NLT0+1
  620 CONTINUE
C
      IPROF(1)=1
      IPROF(2)=1
      IPROF(NL)=1
      IPROF(NL-1)=1
C
C
C
      IF(JAY.EQ.1) WRITE(5,1300) (IPROF(L),L=1,NL)
C
C
C
C
C
C
C     TYPE 1 DETECTION-
C           AT LEAST FIVE NEG NUMBERS IN A ROW IN PROFILE
C
C     TYPE 2 DETECTION-
```

```
C               AT LEAST FOUR OUT OF A CONTIGUOUS SEVEN
C               NUMBERS IN PROFILE ARE NEGATIVE BUT NOT
C               FIVE CONTIGUOUS, OR THREE CONTIGUOUS
C
C               NOTE THAT THE SEARCH FOR TYPE 1 TAKES
C               PRECEDENCE, EXCEPT THAT TYPE 2 SPANS A
C               WIDER INTERVAL.  THE SEARCH IS STRICTLY
C               ONE DIRECTIONAL, FROM THE TOP OF THE PROFILE
C               ARRAY TO THE BOTTOM.  THIS SEARCH PATTERN
C               FEATURES SOME AMBIGUITY, BUT NOTHING SERIOUS
C
C
C       TYPE A CENTROMERE-
C               SKEWED, LOWEST DIP IN PROFILE IS FIRST OR
C               LAST ONLY IN SEQUENCE OF NEG NUMBERS THAT
C               INDICATE THE CENTROMERE.  THIS IS EXPECTED TO
C               OCCUR NEAR THE END (TOP) OF THE CHROMOSOME.
C
C       TYPE B CENTROMERE-
C               SYMMETRIC, LOWEST DIP OCCURS CORRESPONDINGLY
C               POSITIONED IN THE PROFILE TO THE CENTER OF
C               THE CENTROMERE IN THE CHROMOSOME.
C
C
C
        K=0
        IFETUR=0
  700   K=K+1
        IF(K.GT.NL-4) GO TO 750
        IF(IPROF(K).GE.0) GO TO 700
        IF(IPROF(K+4).GE.0) GO TO 710
        IF(IPROF(K+3).GE.0) GO TO 710
        IF(IPROF(K+2).GE.0) GO TO 710
        IF(IPROF(K+1).GE.0) GO TO 710
C
        IFETUR=IFETUR+1
        KFETUR=1
        JFETUR(IFETUR)=KFETUR
C
C       SCAN TO POS NUMBER
C
        K=K+4
  701   K=K+1
        IF(IPROF(K+1).LT.0) GO TO 701
        GO TO 700
C
  710   CONTINUE
C
        NMINUS=1
        DO 720 KL=1,6
        KK=KL-2
        IF(K+KK.GT.NL) GO TO 721
        IF(IPROF(K+KK).GE.0) GO TO 720
        NMINUS=NMINUS+1
  720   CONTINUE
  721   CONTINUE
C
        IF(NMINUS.LT.4) GO TO 700
C
        IFETUR=IFETUR+1
        KFETUR=2
        JFETUR(IFETUR)=KFETUR
        K=K+4
  731   K=K+1
        IF(IPROF(K+1).LT.0) GO TO 731
C
        GO TO 700
C
C
C
  750   CONTINUE
C
        WRITE(5,4000) (JFETUR(JF),JF=1,IFETUR)
C
 4000   FORMAT(' FEATURES: ',20I3)
C
C
```

```
C
      IF(NLT0.GT.NL/3) GO TO 940
      GO TO 941
 940  CONTINUE
C
      WRITE(5,1094)
 1094 FORMAT(' NOT A CHROMOSOME')
C
      GO TO 950
C
 941  CONTINUE
      IF(IFETUR.EQ.0) GO TO 900
      IF(IFETUR.EQ.1) GO TO 910
      IF(IFETUR.EQ.2) GO TO 920
      IF(IFETUR.EQ.3) GO TO 930
C
      GO TO 940
 930  CONTINUE
      GO TO 950
C
 920  CONTINUE
      IABIND=JFETUR(1)+JFETUR(2)
      IF(IABIND.EQ.2) WRITE(5,1292)
      IF(IABIND.EQ.3) WRITE(5,1392)
      IF(IABIND.EQ.4) WRITE(5,1492)
 1292 FORMAT(' CHROMOSOME IS BICENTRIC, OR BADLY TWISTED')
 1392 FORMAT(' CHROMOSOME MAY BE BICENTRIC')
 1492 FORMAT(' CENTROMERE LOCATION DOUBTFUL - PROBABLY NORMAL')
      GO TO 950
C
 910  CONTINUE
      IF(JFETUR(1).EQ.1) GO TO 911
      WRITE(5,1291)
      GO TO 912
 911  WRITE(5,1191)
 912  CONTINUE
 1191 FORMAT(' SINGLE CENTROMERE IS WELL DEFINED - NORMAL')
 1291 FORMAT(' SINGLE CENTROMERE POORLY DEFINED - PROBABLY NORMAL')
      GO TO 950
C
 900  CONTINUE
      IF(NL.LT.30) GO TO 901
      WRITE(5,1902)
      GO TO 903
 901  CONTINUE
      WRITE(5,1901)
 903  CONTINUE
C
 1901 FORMAT(' NO CENTROMERE FOUND,',/,
     1   ' COMMON IN SMALL CHROMOSOMES - PROBABLY NORMAL')
 1902 FORMAT(' NO CENTROMERE FOUND - POSSIBLE ACENTRIC')
C
C
C
C
 950  CONTINUE
C
C
C
C     ****************************************
C
C
C
C
 310  CONTINUE
C
      WRITE (5,3030)
      CALL APHASE(13)
      CALL CLOSE(OBUF)
C
C
 1000 FORMAT(I10)
 2000 FORMAT(3X,3913)
 3000 FORMAT('0CHROMOSOME ',I2)
3030  FORMAT('1')
      CALL EXIT
      END
```

We claim:

1. An operator assisted system using a programmed computer for producing karyotype images from a slide mounted on the stage of a microscope, said slide having a plurality of dispersed metaphase chromosome spreads, comprising

moving said stage under instructions of said programmed computer connected to control said microscope to successively present said plurality of dispersed metaphase chromosome spreads to the optics of said microscope,

storing the location of each spread, thereby automatically prescanning said slide for chromosome spreads,

moving said stage under instructions of said programmed computer to place the slide motionless on said stage at each successive chromosome spread location, thereby enabling an operating to view each successive chromosome spread to inspect the chromosome spread and determine whether it is acceptable for the purpose of analysis or not,

deleting under operator control the location of each spread determined not to be acceptable thereby establishing a list by location of which the chromosome spreads are acceptable,

again moving said stage under instructions of said programmed computer for generating a digital picture of each of said acceptable chromosome spreads,

arranging the chromosomes in the digital picture of an acceptable chromosome spread in a karyotype format, and

producing a visible image of the karyotype format for each acceptable chromosome spread.

2. A system as recited in claim 1 wherein said step of producing a visible image of the karyotype format for each acceptable chromosome spread includes,

displaying said karyotype format on a gray scale display,

correcting any errors to provide a corrected karyotype format, and

printing said corrected karyotype format.

3. A system as recited in claim 1 wherein said step of moving said stage under said microscope to successively present said plurality of dispersed metaphase chromosome spreads to the optics of said microscope includes

moving said stage with a scanning motion in successive predetermined motion increments underneath the optics of said microscope,

detecting whether or not a chromosome spread is present within the distance of the predetermined increment of motion, and

storing the location data for each detected chromosome spread.

4. A system as recited in claim 3 wherein said step of generating a digital picture of each of said accepted chromosome spreads includes,

successively moving said stage to the undeleted locations of accepted chromosomes spreads to position each such accepted chromosome spread under the microscope optics,

automatically focusing the optics of said microscope on an accepted chromosome spread positioned thereunder,

photographing each said accepted chromosome spread through said focussed microscope optics in a manner to generate successive picture elements, and

digitizing each picture element generated in photographing a chromosome spread.

5. A system as recited in claim 1 wherein said step of arranging the chromosomes in the digital picture of an acceptable chromosome spread in a karyotype format includes

locating each chromosome in said digital picture of an acceptable chromosome spread,

orienting each chromosome in a predetermined direction,

measuring each oriented chromosome,

classifying the oriented chromosome on the basis of measured length and centromeric index, and

composing the karyotype format from the classified and oriented chromosomes.

6. A system as recited in claim 5 wherein after the step of locating each chromosome in said digital picture of an acceptable spread there is included the step of

assigning a different number to each chromosome which has been located.

7. A system as recited in claim 8 wherein said step of composing the karyotype format from the classified and oriented chromosomes includes

displaying said composed karyotype format on a gray scale display, and

correcting any chromosome orientation and classification errors.

8. A system as recited in claim 4 wherein the step of producing a visible image of the karyotype format includes

converting the digitized picture elements into analog picture elements, and

printing a picture responsive to said picture elements.

9. An operator-assisted system using a programmed computer for producing karyotype images from a slide mounted on the stage of a microscope, said slide having a plurality of dispersed metaphase chromosome spreads, comprising

means for moving said stage under instructions of said programmed computer connected to control said microscope to successively present said plurality of dispersed metaphase chromosome spreads to the optics of said microscope,

means for storing the location of each spread, thereby automatically prescanning said slide for chromosome spreads,

means for moving said stage under instructions of said programmed computer to place the slide motionless on said stage at each successive chromosome spread location, thereby enabling an operator to view each successive chromosome spread to inspect the chromosome spread and determine whether it is acceptable for the purpose of analysis or not,

means for determining under operator control the location of each spread determined not to be accpetable thereby establishing which of said chromosome spreads are acceptable,

means under instructions of said programmed computer for generating a digital picture of each of said acceptable chromosome spreads,

means for arranging the chromosomes in a digital picture of an acceptable chromosome in a karyotype format, and

means for producing a visible image of the karyotype

format for each acceptable chromosome spread.

10. A system as recited in claim **9** wherein said step of producing a visible image of the karyotype format includes

means for displaying said karyotype format on a gray scale display,

means for correcting any errors to provide a corrected karyotype format, and

means for printing out said corrected karyotype format.

11. A system as recited in claim **9** wherein means for moving said stage under said microscope to successively present said plurality of dispersed metaphase chromosome spreads to the optics of said microscope includes

means for moving said stage with a scanning motion in successive predetermined motion increments underneath the optics of said microscope,

means for detecting whether or not a chromosome spread is present within the distance of the predetermined increment of motion, and

means for storing the location data for each detected chromosome spread.

12. A system as recited in claim **9** wherein means for generating a digital picture of each of said accepted chromosome spreads includes,

means for successively moving said stage to the undeleted locations of accepted chromosome spreads to position each such accepted chromosome spread under the microscope optics,

means for automatically focusing the optics of said microscope on an accepted chromosome spread positioned thereunder,

means for photographing each said accepted chromosome spread through said focussed microscope optics in a manner to generate successive picture elements, and

means for digitizing each picture element generated in photographing a chromosome spread.

13. A system as recited in claim **9** wherein the means for locating each chromosome in said digital picture of an acceptable spread includes

means for assigning a different number to each chromosome which has been located.

14. A system as recited in claim **9** wherein means for producing a visible image of the karyotype format includes

means for converting the digitized picture elements into analog picture elements, and

means for printing a picture responsive to said picture elements.

15. A system as recited in claim **9** wherein said means for arranging the chromosomes in a digital picture of an acceptable chromosome spread in a karyotype format comprises

computer means programmed for locating each chromosome image in an acceptable digital spread, for orienting each chromosome image in a predetermined direction, for measuring each oriented chromosome image for classifying the oriented chromosome images, and for composing the karyotype format from the classified and oriented chromosome images.

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